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Operation of a braiding machine. Twenty-four spools of asbestos yarn will tape round the asbestos fibre core as it is drawn through a die, producing a soft fibre rope enclosed in strands of asbestos yarn. (*Nurnberg photograph*)

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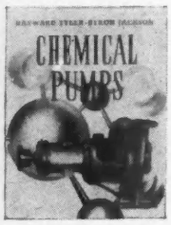

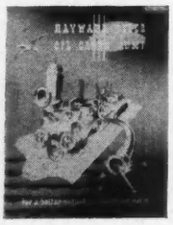

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June 30	Miscellaneous stores	Returned Stores Group, Reed Hall, Colchester, Essex	Fenn Wright & Co., (Dept. J), 146 High Street, Colchester, Essex. (Tel.: 73171)
July 4-5	Miscellaneous stores	Central Ordnance Depot, Bicester, Oxon.	Midland Marts Ltd. (Dept. J), Market Square, Bicester, Oxon, (Tel.: 73)

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ENGINEERING Impact

of an Electrical Ten Year Programme

MR. STANLEY F. STEWARD, director of the British Electrical and Allied Manufacturers' Association, put forward at the Eastbourne British Electrical Power Convention last week the proposal that a ten year plan for the electrical industry should be prepared by a thorough joint study of the supply and manufacturing interests, and that it should be regularly reviewed.

The essential point that emerges from consideration of plans and of the widespread shut down of power supplies on 15 May is that it is no good having excellent plans if they are frustrated and prevented from working. There is no doubt that the Central Electricity Generating Board and the area boards know what is required and have their estimates of the likely future demand worked out at least with general local accuracy.

The trouble has been, and continues to be, the delays in granting permission for essential work to be put in hand. In the last resort this is a political problem. Electricity generation and distribution, as nationalized industries, are dependent upon Government decision for the proportion of the national investment they are allowed to consume.

Plainly the rate of investment, particularly perhaps in the distribution systems, has not been high enough. To be advancing towards next winter in the hope that it will be as mild as the last and so allow industry to go on working uninterrupted by power failures is a particularly silly gamble.

The director of BEAMA declared at Eastbourne that when economic growth and industrial expansion were essential for survival the dependence on good weather to avoid load shedding was inexcusable. More and more the judgment of observers both in this country and abroad is that the United Kingdom needs a great sweep forward in the total volume of its national product, and its productivity. To this end it should be an object of national pride that the resources of electric power available are kept constantly ahead of the developing demand. And one of shame that the reverse is consistently the case.

A Model of Growth by Providing a Service

FROM demonstrating the complexities of stress patterns to leaping in one bound over the language barrier, the model, whether for design or exhibition purposes, has grown swiftly in its importance to manufacturing industry.

The model making industry itself is small and diverse. Some half-dozen main firms are the most clearly visible part of the business, closely followed, with no less high standards of work, by many individuals and temporary arrangements based on the reasonable premise that in certain instances one able craftsman with a good workshop and the right cooperation from his client can produce a model of the highest quality.

For the study of bridges, designing the layout of factories, of highly complex chemical plant, factories and mechanically equipped offices, the model has been more and more brought into use. At the same time there has been an accompanying demand on the model makers.

The demands of the engineering concern that is going to submit a model with its tender, or is going to use models in getting the details of its new plant right, are for realism—it is no good treating important related parts of the subject in a general fashion—and for accuracy and still more accuracy.

In a growing industry, one of the most swiftly expanding concerns is Westway Models, of Acton, West London. The example given by the company of its breadth of work, from a prototype egg cup to a major civil engineering project, serves for an illustration of the range of activities of all the model makers. From models for the aviation industry the company has grown to serve a variety of capital and consumer goods firms.

Models, an essential part of much development work, are themselves progressing to new industries and fresh applications.

Orders and Output Rising Again

ONE of the most interesting figures in the replies to the Federation of British Industries' eleventh inquiry into industrial and export trends is that of 53 per cent of the companies concerned, who said that their output was up to capacity, coupled with 45 per cent who reported that their current output was below what it could be. These were exactly the same percentages as in the tenth report, last February.

The inference appears to be that while both the last inquiry and the recently issued eleventh report hold serious portents for the future, for the moment the day to day position goes along not significantly changed.

Despite the worsening trade performance shown by the balance of United Kingdom trade in May, the dwindling confidence of the 701 firms who help the FBI in this inquiry has evidently turned to a more optimistic view of the prospects. Back in February the previous report outlined a position of falling orders, rising stocks, less labour difficulties but also less optimism. The FBI commented that there was some hope the disturbing trend would be halted.

The new set of answers show that in some ways this hope has been realized. The level of output has increased at 38 per cent of the companies, is down at only 13 per cent and is the same at 48 per cent. Some 36 per cent now expect their total orders to rise over the next four months (against 26 per cent in February) only 18 per cent expect a drop in the next four months (31 per cent last time). There is a substantial middle group of 41 per cent (38 in February) who expect the level of their total orders to remain the same.

While the heavy spending required in research and development, in modernization and simply maintaining plant at a competitive and up-to-date standard is in no way likely to diminish, the report shows that the income providing for all this goes on being steadily eroded. Average unit costs of production were up in 50 per cent of firms, an extremely high proportion, down in only 6 per cent, and unchanged at 42 per cent.

Not surprisingly average profit margins per unit of output were down in 45 per cent of companies, increased at only 9 per cent, and remained steady at 45 per cent.

Average selling prices had dropped for 11 per cent of those replying, stayed the same for 64 per cent and had actually risen for 24 per cent.

of Better Prospects at Home than Overseas

WHEN the FBI followed up its inquiry with detailed probing of the respondent companies' relation to exports it was found that 499 companies out of the total 701 had a significant proportion of exports. Taken overall, about 25 per cent of their output was sent abroad.

That the percentage of companies in this category was not closer to the total, and that only a quarter of their output was exported, is a sharp reminder of the room for improvement on its export efforts existing in industry. Immediate hopes of a substantial improvement can hardly be nourished on the inquiry's findings that there is less hope of improvement in the overseas sales than in the home market.

Almost a third of companies report that over the past four months the rate of their export orders has increased, just over a fifth said they had fallen. A third also reported that the level of their export deliveries had gone up, a little fewer than a fifth said that they were down.

Export prices were overwhelmingly (49 per cent) given as the cause of difficulty in selling more abroad. The next factor making the obtaining of orders more difficult, comparative delivery dates, was a long way behind (19 per cent).

While for 20 per cent of exporting firms the average prices at which orders are being booked has fallen, the same proportion report a shortening of the delivery dates in export business.

After all the replies and the summarized information are absorbed the conclusion seems to be the unavoidable one: that prices are the critical factor, much more than production facilities, that unit costs appear to be rising, just at the time when export success is more needed than ever, despite the fairly obvious belief that the home market is an easier wicket.

It is unlikely that the Government authorities, pondering whether to apply at touch of the brake, will have failed to notice the warning.

The Steel Industry Breaks All the Records

MORE steel produced, a greater amount used, more steel exported and a record level of steel imports—this is the picture of the iron and steel industry presented in the annual report for last year released this week by the Iron and Steel Board.

One of the most significant features of the year was the stock position. During 1959 producers, consumers and merchants had taken 650,000 ingot tons of steel out of stock. Last year 1,850,000 tons were put into stock, more than four times the amount stockpiled in the last year—1957—of stock accumulation.

With the growth of industrial activity up to the limits of available labour, and despite the slump in the car industry, home demand was up to 20·23 million tons (1·6 million more than in 1957).

When export demand and the call for increased stocks are added, the total demand reached 26·16 million ingot tons. More than 3 million tons above the previous record level (22·97 million in 1957) this was met with production of 24·30 million tons (previous best 21·70 million in 1957) plus 0·25 million tons of re-usable steel and 1·61 million tons of imports.

The Iron and Steel Board make the point that in previous periods of high demand for steel there have been complaints from consumers that delivery promises not only lengthened but became unreliable. Delivery delays long after expected schedules have on these former occasions caused costly disruptions to manufacturers' programmes. This time, while pressure of demand has lengthened delivery quotations to six months or more, no substantial complaints of broken delivery dates have reached the Board.

Price Advantages

When so much attention is on a possible move into the Common Market, the Board's comparison of international prices is more significant than ever. UK producers have the most marked price advantage in thick plate, thin sheet and in all specifications of tinplate. The greatest price advantage for the firms in the European Economic Community lies in re-rolled bars and sections, wire rods and hot rolled strip in basic Bessemer qualities

Most serious for the future are the Board's figures on fuel prices. The Durham price of coking coal at the pithead is now £5 10*s* 3*d* a ton, comparing with a post-revaluation price in the Ruhr of £5 9*s*. Coking coal costs in the European Coal and Steel Community have been stable for more than three years and the indications appear to be that they will stay so.

A much wider divergence exists between British coking coal delivered to coastal works and the price of United States coking coal—hence the recent fracas over the Steel Company of Wales' efforts to stay competitive by using the Virginian coking coal now available.

British coking coal delivered to coastal works costs £5 18*s* a ton. The price of the American product, aided by low freight rates and lower pithead prices, is about £5 a ton. The menace of this is not only that we, by propping up our own miners' security of employment in disregard of long term factors, will go on raising steel production costs by using other than the cheapest available fuel. It is also that the High Authority of ECSC expects these American supplies, at below £5 10*s* a ton, to be available for a long period ahead and in substantial quantities for European coastal works.

The price of steel, now up by an inadequate 1 per cent, is so essential a factor in every detail of our export effort that it should be clear that it is in even the miners' own interest to keep costs down wherever possible.

Models: Engineering's Universal Language

Besides bridging language barriers, models can convey to those at different levels of engineering a variety of information.

ANYTHING produced in miniature has a peculiar fascination to the beholder. This may be because a model makes it possible at one glance to comprehend form, appearance and dimensional scale far better than could a drawing or picture or even an inspection of a full size prototype.

This fact has been appreciated for many years and, because it has, models have played a significant part in the development of inventions and the planning of many large schemes.

Models are for more than just looking at: they have definite utilitarian functions to perform and can be a great aid to the designer.

Bassett-Lowke Limited, one of the foremost model makers in this country started life in the model railway world and have had considerable influence on the development of this fascinating hobby. Out of this has grown an organization based on craftsmanship which can deal with any engineering or architectural subject in three dimensions. The greater portion of their output is of models for industrial purposes and duties. These duties can be classified in three categories:

Educational

Removal of a slabbing mill at the Abbey Works of the Steel Company of Wales and installation on the same site of a larger mill took place about three years ago. The old mill had a capacity of 48,000 tons a week and the new one 60,000 tons. To avoid disrupting production too much the changeover was scheduled to be completed in 14 days—it actually took 1½ days less.

An operation of such magnitude called for planning of a high order, and the changeover was worked out to the last detail, every item of plant and every movement of personnel being listed in advance. To ensure that all personnel concerned were fully briefed and that the planned movements of plant would go as intended, scale models of both the old and the new plant were made and with these the detailed moves were demonstrated and rehearsed. Fig. 1 shows a model of the old slabbing mill and foundations and Fig. 2 shows the work in progress. Without careful planning, as is seen from the photograph, it would have been difficult to sort order out of the chaos.

A series of models of Hinkley Point nuclear power station were prepared by Bassett-Lowke for educational purposes. The first was an architectural model showing site and development work at plus twenty months. It showed civil engineering work in site clearance, building of reactor foundations and in general was a record of the progress of the job.

The second model to a larger scale $\frac{3}{16}$ in to 1 ft was of the reactor building. As can be seen in Fig. 5 it shows a section through the reactor revealing the biological shield, control rods going into the graphite moderator and the fuel elements. An interesting feature was the device for loading the fuel elements. Normally nobody can see what is done, they are pushed down a hole and disappear, but the model showed what happens.

A third model of the generating room showed the turbines and, in particular, the pipe runs between the ancilliary equipment which goes with such a plant. These three models are used for instruction purposes but they also serve to prove the practicability of the design, especially in respect of the pipe runs.

The speed at which projects develop today does not allow one designer to do and keep in touch with the whole job; models can span a whole project and keep abreast of modifications.

Bassett-Lowke have been approached by many engineering companies to instal model makers in works but they have found that it does not work out in practice. Of course many concerns have their own model making departments, especially in the chemical engineering field, but these in the main are concerned with pipeline layouts. Machinery layouts can be worked out on squared paper floors for a designer to layout the shops.

Experimental and Development

This type of model can be an economical method of proving the efficiency of any projected improvement scheme or solving problems of production before laying down expensive plant or machinery.

Bassett-Lowke cooperated with a firm of cablemakers in the development of a rig which would control the tension set up in reeling off long lengths of marine cable. The whole scheme was built in miniature and with the simplest amount of instrumentation all the loads could be actually measured at any stage.

Laboratory test rigs also come within this category, such as one recently developed for British Oxygen. This equipment was made to cut down the test period of carbide from 4 hours to ½ hour and consisted of mechanically driven feeds which accurately fed the raw material into a glass generating vessel and required no further attention other than loading and switching on.

Pilot schemes such as the two mentioned were worked out in this way and then developed further.

Publicity and Record

Many models form a record of a project for display at exhibitions and for publicity in connection with sales promotion.

Very often it is impossible to show the actual project—a rolling mill for example—to the public, but a model can do this and brings the project into focus. Models have the ability to allow people to see something as they would never otherwise be able to see it.

Take a ship: close to a real one at the quayside all that can be seen is the slab-sided hull, and no overall impression gained. At sea, at a distance from the observer, detail is lost. A ship is perhaps one of the finest examples of combined engineering and aesthetics, and the model is the best medium for conveying this impression.

Fig. 4 shows a publicity model of the RMS

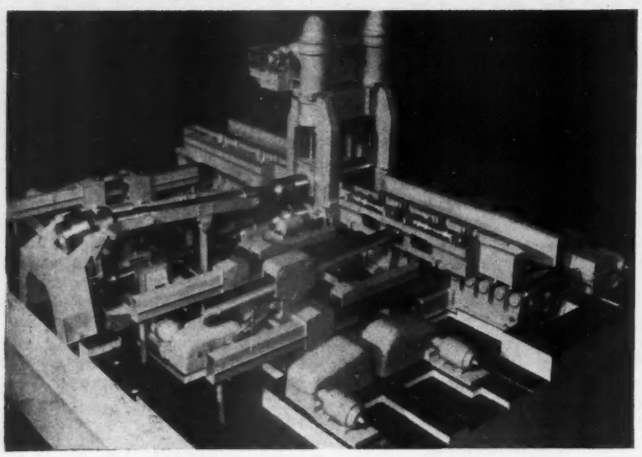


Fig. 1 (left) Model of the old slabbing mill and foundations which were removed from the Abbey Works of the Steel Company of Wales about three years ago. The model, built to a scale of ½ in to1 ft, was used to train personnel who were to do the job of dismantling. Fig. 2 (right) shows the work in progress.

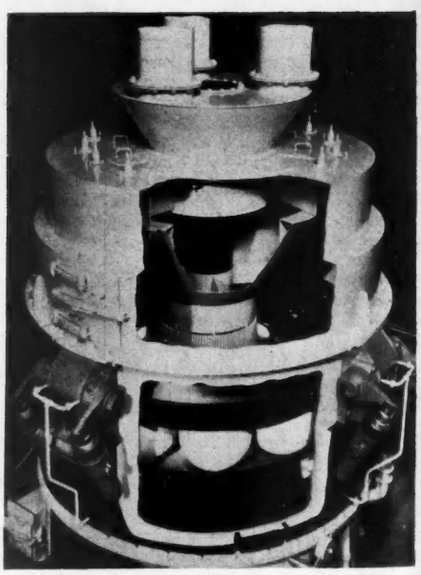
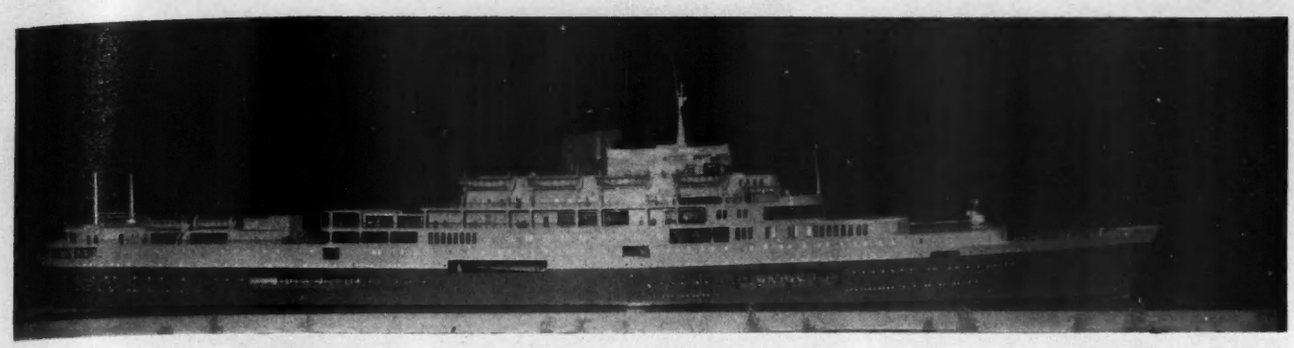


Fig. 3 A working model of a pulverising mill built to a scale of 1½ in to 1 ft for Babcock and Wilcox. Such a model might be used for development work.



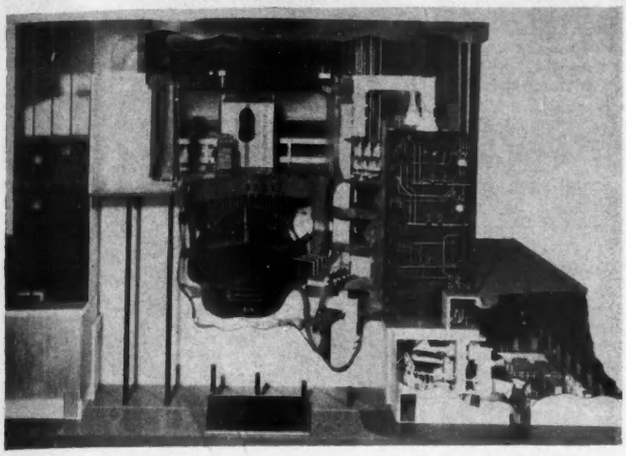


Fig. 4 (above) A publicity model of the RMS Windsor Castle. At the quayside, all that can be seen of a ship is the slab-sided hull. At sea, at a distance from the observer, detail is lost. A model allows the ship to be seen in a new light.

Fig. 5 (left) The second of three educational models of Hinkley Point nuclear Power Station. This one, built to a scale of $\frac{3}{16}$ in to 1 ft, was of the reactor building and was sectioned through the reactor to show its various components.

Windsor Castle, 23 ft long, which took 5,000 manhours to make. Through transparent sections in the hull and deckhouses, viewers can observe passenger life at sea. There has been considerable increase in the use of accurate detailed models of the interior of ship's cabins: they give prospective passengers an opportunity of examining the general arrangements and amenities provided for them on a sea voyage.

The point of focus applies particularly to engineering plant. A good example is Richard Thomas and Baldwins electrolytic tinning plant. The plant is 300 ft long: no one person can possibly see at one go the whole of the process which is continuous and controlled by an electronic eye. The model which Bassett-Lowke produced was 15 ft long and it immediately became possible to comprehend both plant and process.

Models trace the development of engineering or science. This is obvious from a visit to the Science Museum at South Kensington. Bassett-Lowke's model of A. E. Reed's board mill now in process of completion is an historic record of the process.

Full Size Models

Many items required for exhibition purposes are too costly to exhibit and/or transport. Capital goods are too expensive to allow them to spend time in an exhibition hall and delivery periods frequently too tight. Floor loadings are often limited and in all these cases wooden models can overcome the objections.

A large induction motor by Bruce Peebles of Edinburgh shown at an exhibition at Olympia last year was made of wood and weighed less than a ton—the real one would have weighed eighty. The finish was so realistic and looked for all the world like metal that when it arrived on a three-ton lorry at the exhibition, the staff were completely taken in and organized the large crane ready to lift it.

How the Designer Can Help the Model Maker

In making an inquiry for a model, provide general arrangement drawings, photographs, if possible, and a brief specification of the object or process it is desired to bring into miniature. Give an indication of the size of the model or the scale required; this enables the model makers to give a rough indication of the cost, and put forward suggestions regarding any sectionalizing work essential to demonstrate functional parts of the structure.

The more information the client can provide the better and quicker the model maker can carry out the work. Naturally the model maker comes to have a superficial knowledge of the workings of some projects and often, because of this, the client credits him with more than he does know. For example, a firm asked Bassett-Lowke for a model of a boiler to raise 30,000 lb of steam per hour and another to raise 20,000 thinking they would know what was required. The inquiry was as vague as that.

Between the extremes of the fully detailed model serving to permanently record a great project to the simplified model designed to concentrate attention on special features is a vast field in which the model will serve a definite and valuable purpose. This is the era of specialization, when engineering and scientific terms and intricate drawings can be readily understood by very few. The only universal language is the three-dimensional model which reduces the elaboration of a vast and complex plant to a clear picture well within the compass of human perception.

Bassett-Lowke Limited, 18 to 25 Kingswell Street, Northampton.

Simulating Movement on a Flat Picture

The high capital outlay in the production of working models and colour films has deterred many a concern from using such aids for instruction and sales purposes.

Besides the expense, it is often difficult to portray movement in the sense of showing processes at work. Such an example might be the flow of fuel in a combustion chamber, showing how it mixes with the air to form a combustible gas, or perhaps the internal working of a furnace.

A new animated display device known as the "Movotron" is now available and this can effectively show the action of a piece of machinery or the working of a process such as the flow, expansion or contraction of semi-solids, liquids or gases. Basically the unit consists of a circular disc on to which a photograph or line drawing is mounted. The parts which require simulated movement are coated with a thin metallic foil. These foil strips are engraved with a pattern according to the type, speed or direction of motion required. The natural colours are then added to the illustration which, when it is placed in the holder inside the unit and illuminated, "comes to life".

The actual animation comes from reflected light being thrown over the disc, and by moving this light in a rotary manner the movement becomes apparent. The light source consists of 4 lights—8 for the larger units—which rotate at about 45 rpm on the periphery of and in front of the disc. The lights themselves are of course hidden from the observer.

For the smaller units 15 W lamps are used, but the bigger units use lamps of 150 W. A 45 W motor drives the lights round and it can be appreciated that the speed of rotation governs the speed of animation. Reversal of the lights reverses the animation.

Five sizes of unit are available giving viewing diameters of 9, 12½, 22, 28 and 39 in. The disc forms the back of the cabinet and the driving motor is fitted inside. All the units are easily transportable and work from a normal mains supply.

The Movotron has proved useful in film making. An example quoted by the manufacturers concerns a client who wanted to make a film of four types of stokers. It was desired to produce on film the operation of the various types. To do this would have meant producing artwork for each version and suitably modifying them for each sequence of operation. It was estimated that the cost would have been about £1,500. By using the Movotron unit, all that was required was to produce the four individual types of stoker and animate each one in the manner previously described. Each of these was put into the Movotron and filmed, the four types being reproduced and combined on one film. By this method the cost was said to be about £450.

The process will allow designers to demonstrate to potential clients and to other interested parties "live" presentations of their products at work.

Technical Designs Limited, 86/88 Edgware Road, London W2.

Models of Perfection in Silver

The production of silver models for presentation purposes is a highly specialised field. That this is so is in evidence at the well-known Crown jewellers, Garrard and Company, who set up a separate department nearly 200 years ago to concentrate solely on this type of work.

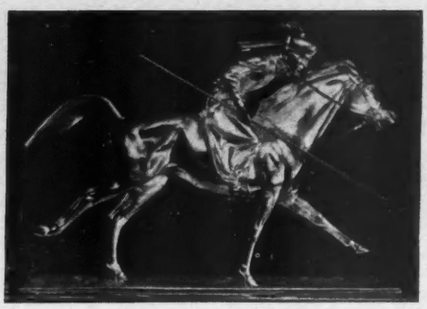
Since then historical events have been faithfully recorded in contemporary silver and the thousands of models made during this period include castles, oil wells, soldiers in uniform and animals of all descriptions. With military silver in particularly, minute attention to detail is essential. A highland regiment was known to complain on one occasion of a slight variation in the pattern of the socks depicted on a silver statuette of a soldier of the regiment.

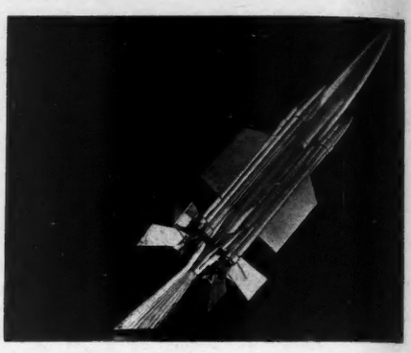
While many standard models are on permanent display in the Garrard showrooms, more important pieces are invariably made to order. On receipt of such a commission, drawings and designs are prepared by staff artist Mr. A. G. Styles. From these a wax model is prepared and after this has been checked in detail by the client it is plaster moulded and, from this, the white metal cored casting is obtained. This in turn is sand cast in silver and, when assembled, filled with pitch to allow detail lost in reproduction to be retained without distortion to the overall shape of the casting.

Throughout the whole series of operations, only the simplest form of hand tools are used. The pitch is then warmed and run out and the parts cleaned for final assembly. For this last stage, specially prepared silver-based solder is required having varying melting points so that the fixing of one part will not cause the solder used elsewhere to melt. The solder has also to contain a sufficient quantity of silver to pass the stiff tests of the Assay Office, or the model will not receive its coveted Hall Mark.

When final cleaning and polishing have been carried out and the completed model has been given a last inspection by the staff artist, it is ready for Hall-Marking.

Garrard and Company Limited, 112 Regent Street, London W1.





This tent-pegging horseman (above) was cast from an original wax model as described in the article. The model of the bus and the guided missile are accurate records and must pass critical inspection.

Moving Map Display for Aircraft Navigation

A topographical display instrument intended as a navigational aid for pilots and navigators has been developed by the Royal Aircraft Establishment, Farnborough, Hants.

In these days of fast air travel, by the time the navigator or pilot has plotted his position on the map the aircraft has moved several miles. This new device actually shows the current position and track of the aircraft superimposed on a projected image in colour of a topographical map at a scale of either 1 : 500,000 or 1 : 1,000,000. At the large scale a circular area of 45 nautical miles in diameter is displayed.

The maps are condensed by microfilming in colour on 35 mm motion picture perforated film which is capable of being driven simultaneously in two ordinates corresponding to the components of the aircraft's motion north/south and east/west. The film is also capable of being rotated for track orientation. The image is produced by optical projection.

Determinations of ground speed and track are made entirely from equipment carried in the aircraft, by the Doppler and compass system. The map display is driven from a navigational computer which combines drift angle with heading to determine ground track and resolves the ground speed into N/S and E/W components. The computer also has a memory so that adjustments can be made during flight and the correct position rapidly re-established after completing the adjustment.

Considerable geographical areas can be covered by this means and the aircraft has complete tactical freedom within the area. Such an arrangement is said to allow more freedom than can be obtained from the strip maps normally used. The whole of Europe including North Africa can be stored on 9½ ft of film.

The instrument was developed by a team in the Instrument and Photographic Department at RAE and was first flown in February of 1960. After successful flights in the UK, longer jet flights were undertaken over planned routes in Europe of up to 1,500 nautical miles with "complete success," RAE report. The display remained in correct synchronism with the ground throughout within close limits.

Propeller Brake Saves Time on the Ground

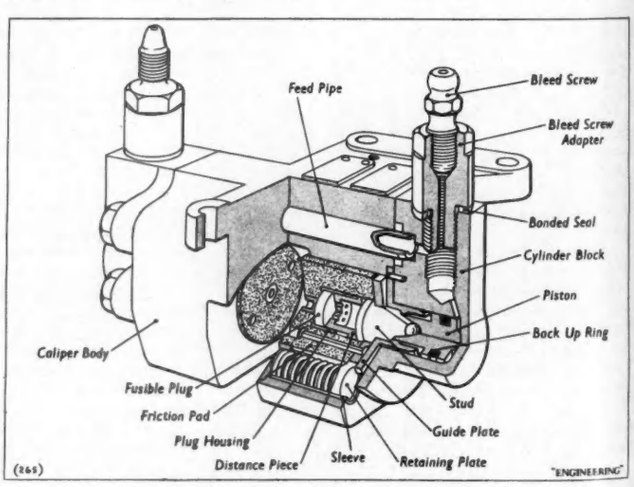
In these days of fierce airline competition anything which helps to reduce turnround time on the ground soon earns its keep.

The Dunlop propeller brake enables the propellers of turboprop aircraft to be brought to rest within seconds of the engines being cut. This allows maintenance crews immediate access to the power plants and propellers, allows passengers to alight without waiting for the slipstream to stop and affords immediate maximum safe manoeuvring room for servicing vehicles. On some aircraft the opening of the passenger door and the lowering of the alighting steps automatically applies the propeller brake on the associated engine(s).

The unit consists basically of two opposing piston-actuated friction pads contained in a calliper body. The engine speed at which the brake may be applied is mandatory, and a safety fuse is incorporated to prevent damage in the event of inadvertent application at higher speed.

The brake is standard equipment on such aircraft as the Vickers Vanguard and Viscount, Handley Page Herald and the Avro 748.

Dunlop Rubber Company Limited, Aviation Division, Holbrook Lane, Foleshill, Coventry.



The propeller brake plays a part in reducing aircraft turn - round times on the ground. It allows propellers to be brought to rest within seconds of the engines being cut.

Plain Words

By Capricorn

YEARS ago, when I was doing my square bashing, a courageous sergeant let us loose on the firing range. This was a dangerous manoeuvre, but one made necessary by a decree from above that our passing-out parade should include a presentation of alleged certificates of marksmanship.

So we lay on our stomachs 25 yards from a row of tarkets and squeezed our trigger fingers. When we opened our eyes again each target had a roughly similar number of bullet holes except for mine, which had twice the normal quota, and the one on its right, which had none. Targets, apparently, were all much of a muchness to the zombie alongside me.

But the sergeant, who was something of an intellectual giant, was equal to the situation. The zombie must obviously shoot at the target on *his* right in order to hit the one in front of him. Indeed, very probably the sergeant was already one jump ahead and appreciating the zombie's possibilities in countering out-flanking movements on the left.

So the zombie fired at the target on his right—and, regrettably, hit it. The sergeant, his new-found theories on higher strategy shattered, became a bitter man. The zombie's first effort had been exposed as sheer carelessness, not an inherent gift. So the zombie was ordered to re-load and fire at his own target again. Which he did—and hit mine again.

The sergeant was becoming acutely aware of two dozen raw recruits sniggering against their rifle stocks in a manner prejudicial to military discipline. He was also becoming acutely aware that the zombie could probably spend the rest of the day on that range without hitting his own target.

Firmness and justice were therefore called for, and the sergeant was the man to administer them. With an imperious gesture he silenced the sniggers, disarmed the zombie (for which we were all grateful) and called for my target. Holding the much punctured target before him, he solemnly pronounced sentence. Clearly, any man who could not hit the right target was incapable of hitting anything but the outer extremities of anyone else's. The outermost holes would therefore be credited to the zombie and—unavoidably, since someone must have made the other holes—the residue to me.

And that was how I came to be presented with a certificate of marksmanship. It seemed to me to be a little rough on the zombie—after all, if he couldn't hit the enemy he aimed at, it didn't follow that he couldn't put paid to the enemy he did hit. (The sergeant didn't think much of my suggestion that the zombie and I should receive the coveted award jointly.)

Now, however, I see the sergeant's negative system of selection by elimination is a common practice. How many jobs must be held not because the incumbent is a good man but because the others were worse ? Perhaps it is " les autres " who now do the " encouragant."

Letters to the Editor

Making Small Arms in Pakistan

SIR, Your article on small arms (" Army Fire Power: Improved Small Arms," ENGNG., 16 June '61, p. 830) reminded me of the famous village gun factory on the North-West Frontier in Pakistan which I recently visited.

Here I saw being made by workers from five to seventy-five years of age perfect copies of the Lee-Enfield rifle, of famous makes of revolver and beautiful shotguns. One clever worker had designed and made a walking stick shotgun that is extremely ingenious.

In the old days, the bolts of the rifles were stolen from British soldiers but now they are made by hand. The old man in the accompanying illustration with his feet in a hole in the ground, is filing one out. All the machinery is home-made and hand-operated, including a rifling machine which was demonstrated to me by a small boy.

Pakistani villager hand-filing rifle bolts.

The Government of Pakistan would like to see such superb craftsmanship turned to more productive use and are setting up technical institutes in the villages with the hope of training some of the workers to make such peaceful articles as sewing machines.

It remains to be seen whether they can create sufficient incentives to change this hundred-years-old tradition.

Yours faithfully,

AUSTEN ALBU.

House of Commons,
London SW1.
17 June, 1961.

Selwood Orbital Engine

SIR, With reference to my previous letter and to that of Mr. Ernest Owen Davies, on the Selwood orbital engine, both of which appeared in ENGNG., 9 June '61, p. 789, I should like to offer the following further comment:

From the point of view of machine analysis, the Selwood and Zed crank engines are essentially the same, one being an inversion, kinematically speaking, of the other, and both are basically variations of the swashplate class of engine which found favour in the field of hydraulic transmissions.

For automotive applications in particular it is advisable to keep inertia forces as low as possible, and the Zed crank engine with its fixed cylinder block has an undoubted advantage here. A fixed cylinder block also allows a normal distributor to be used for ignition. The curved cylinder bores of the Selwood engine do not seem a good thing to me.

It would be interesting to know why the Zed engine has apparently suffered eclipse, and also what are the views of William R. Selwood Limited about this, since the lessons to be learned from it are presumably applicable to the Selwood engine also.

Finally, the " radical " force which is spoken of in my letter as printed, should, of course, be a " radial " force.

Yours faithfully,

R. W. READER.

Tunbridge Wells.
12 June, 1961.

Two-Element Fluid Couplings

SIR, In recent correspondence with many engineers, I have learned that almost all of them are of the opinion that, in *any* fluid coupling, the torque ratio (torque of runner/torque of impeller) remains 1/1 whatever may be the speed factor (angular velocity of the runner as a percentage of the full-load angular velocity of the impeller).

Most of them also hold, almost as an axiom, that " in *any* rotary hydrodynamic device torque conversion is not possible without the use of a stationary reaction member." Though the fluid coupling may be regarded as a device of minor importance, nevertheless it would seem highly desirable to hold only correct ideas of its characteristics, and of the principles of hydrodynamics that influence those characteristics. It is shown below that the ideas so widely held among engineers are generalizations that are faulty.

The type of fluid coupling that has a baffle and a reserve volume will be regarded as special, and will be excluded from consideration. The inventor who added the baffle and reserve volume was clever enough to sense a large potential demand for a fluid coupling having a special characteristic, and was ingenious enough to devise what would give the desired characteristic. Millions of that type of fluid coupling have been made.

The action of a simple two-element fluid coupling, when transmitting power, must conform to the Law of Conservation of Energy. Let us analyse the action, with this law as our guide. It is easy to deduce from this law that power efficiency (i.e., useful power transmitted/power supplied) = torque ratio × speed factor.

We know from experiment that, when a fluid coupling is transmitting the maximum power of which it is capable, the impeller is rotating at its maximum angular velocity, and the driving torque exerted on the impeller is the maximum possible. We also know that under these conditions the power efficiency is a maximum, say 98 per cent; that the speed factor is a maximum, say 98 per cent; and that the torque ratio is a minimum, and is 1/1.

If we predicate that the torque ratio must remain 1/1 whatever may be the speed factor, we cannot reduce the speed factor. For to reduce the speed factor we have to increase the torque demand of the driven load. But the torque ratio must remain 1/1, so we cannot increase the torque demand, for the impeller is already receiving its maximum driving torque.

However, we know by experience that we can reduce the speed factor by increasing the torque demand of the driven load. This proves conclusively that the torque ratio does not remain 1/1, but increases. As the speed factor decreases, the internal " loss " in the coupling increases; it increases approximately in proportion to the square of (100×speed factor). The power supplied by the impeller has now to be shared by the increased " loss " and by the driven load. Thus the power transmitted to the driven load decreases. The result is that the power transmitted to the driven load has decreased, the power efficiency has decreased, the speed factor has decreased, the " loss " has increased, and the torque ratio has increased.

We can obtain some idea of the variation in torque ratio. But first we have to plot the

" operating " power-efficiency curve on a base of speed factor. This can be done by " reflecting " the scales of power efficiency and speed factor in a vertical line through the point of 50 per cent speed factor. The " reflected " power-efficiency scale becomes our scale of power " loss," and the " reflected " speed factor scale becomes our scale of (100 × speed factor). Using these " reflected " scales we plot the (approximately) " square " curve of power " loss."

We then " reflect " the curve in a horizontal line through the point of 50 per cent on our original power-efficiency scale. This " reflected " curve is our " operating " power-efficiency curve on the original base of speed factor. We can now calculate the torque ratio for a series of corresponding pairs of values of power efficiency and speed factor. We plot these on our base of speed factor, and to a suitable scale of torque ratio. The curve of torque ratio shows that the torque ratio increases as the power efficiency decreases, and as the speed factor decreases. Thus torque conversion is an inherent characteristic of the simple two-element fluid coupling—that has no stationary reaction member.

The torque-conversion characteristic can be improved by modifying the design so as to reduce the " loss." The characteristic might, in this way, be made even better than that of a single-stage torque converter having a stationary reaction member.

Yours faithfully,

G. MONAGHAN.

London.
6 June, 1961.

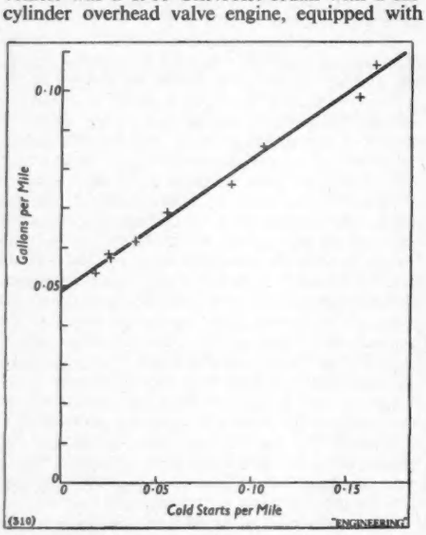
Fuel Consumption in Cars

SIR, You were kind enough to print a previous note of mine concerning fuel consumption in cars (ENGNG., vol. 189, 1960, p. 112) in which I suggested that the apparently higher consumption in local driving is due primarily to more frequent cold starts, each of which involves an increased consumption of fuel during the warming-up period, and that the mean fuel consumption with a warm engine is relatively constant.

In support of this suggestion I described measurements with a Plymouth car which were correlated well by an equation of the form

$$\frac{1}{(\text{mpg})_{\text{actual}}} = \frac{1}{(\text{mpg})_{\text{warm}}} + \left(\frac{\text{gallons}}{\text{cold start}}\right) \times \left(\frac{\text{cold starts}}{\text{mile}}\right)$$

I have now performed experiments with another car which furnished additional support for the suggestion outlined above. The test vehicle was a 1960 Chevrolet sedan with a six-cylinder overhead valve engine, equipped with a single carburettor and automatic choke. " Multi-viscosity " oil was used in the engine.



Effect of cold starts on fuel consumption in cars.

In order to make comparisons with the measurements previously reported, tests were made during the 1960-61 winter covering 2,790 miles and results were obtained for cold-starts-per-mile from 0·0185 to 0·165. The results were correlated well by the equation above, as illustrated in the accompanying graph: the (United States) gallons-per-cold-start was found to be 0·34, and the mpg (warm) to be 20·7. The standard dispersion of the results was less than 3 per cent.

The above value of the gallons-per-cold-start is larger than for the Plymouth (0·243), and the difference is accounted, at least in part, by the fact that the heat capacity of the engine and cooling system is greater for the Chevrolet than for the Plymouth.

It is to be expected that the gallons-per-cold-start is a function of the ambient temperature. To investigate this, further (though less extensive) tests were made in the 1960 summer period, and it was found that the gallons-per-cold-start was reduced, falling as far as about one-quarter of the winter value. It is noteworthy that no variation of the mpg (warm) with ambient temperature was detected, a result which is not unexpected.

These results show to what extent an engine having a small heat capacity and a rapid warm-up is particularly important to overall fuel economy in a car.

Yours faithfully,

P. D. RICHARDSON,
Assistant Professor of Engineering.

Division of Engineering, Brown University,
Providence 12, Rhode Island, USA.
12 June, 1961.

International Industrialization

FOUNDED to promote international collaboration for the advancement of economic knowledge, the International Economic Association are now organizing their second congress, which will be held at the University of Vienna from 30 August to 6 September, 1962.

On the morning of the opening day, there will be a plenary session devoted to a discussion on the problems of economic development, after which the congress will be divided into four sections. These sections will be concerned, respectively, with the determinants of economic development, industrialization and methods of increasing labour productivity, techniques and problems of development planning, and the stabilization of primary producing economies. A plenary session on 6 September will conclude the proceedings.

A fee of $10 will entitle participants to receive copies of all papers, but these will only be available in Vienna and will not be distributed in advance of the meeting. Persons wishing to take part in this event should communicate with Österreichisches Verkehrsburo, 7 Friedrichstrasse, Vienna 1, Austria, who are arranging registrations, travelling facilities and hotel reservations.

Letting Machines Do the Translating

VERY considerable success is likely to attend the first international conference on " Machine Translation of Languages and Applied Language Analysis," which is to be held in the new Glazebrook Hall of the National Physical Laboratory, Teddington, from 5 to 8 September next.

The conference is being organized by the Autonomics Division of the Laboratory with the assistance and cooperation of European and American area committees and is being convened at a time when the participants will be able to engage in a useful and critical review of the progress which has so far been made in connection with machine translating. While being, naturally, of major interest to personnel engaged in research on this subject, the conference should also be of particular importance to persons concerned with the analysis of language and the processing of words in computers.

Altogether, some 40 papers, covering many aspects of machine translation are due to be discussed. Preprints of these papers will be sent to participants before the conference and authors will accordingly be limited to 10 minutes to introduce their communications, so as to allow the maximum time for discussion.

Proceedings of the conference, consisting of the papers and reports of the discussions, will be sent to all delegates as soon as possible after the termination of the conference and will also be on sale at HM Stationery Office. During the course of the conference, interpreters will provide simultaneous interpretations of all sessions into English, French and Russian.

As befits a conference of this importance, an attractive social programme is being arranged. A registration fee of £6 10*s* will be payable, to cover preprints, a copy of the *Proceedings*, lunches, and a sherry party in the evening of the first day, etc. Further details may be obtained from Mr. John McDaniel, National Physical Laboratory, Teddington, Middlesex (Telephone: TEDdington Lock 3222, extension 138).

Exhibitions and Conferences

Arranged in chronological order

Machine Translation of Languages and Applied Language Analysis, International Conference on.—Tues., 5 Sept., to Fri., 8 Sept., at the National Physical Laboratory. Organized by the Autonomics Division, National Physical Laboratory, Teddington, Middlesex. Tel. Teddington Lock 3222.

Packaging Exhibition, International.—Tues., 5 Sept., to Fri., 15 Sept., at Olympia, London W14. Organized by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester 3. Tel. Deansgate 6363.

Microwave Measurement Techniques, Conference.—Wed., 6 Sept., to Fri., 8 Sept., at the Institution of Electrical Engineers, Savoy Place, London WC2. Associated with the conference will be an Exhibition of Microwave Measurement Techniques. Organized by the Electronics and Communications Section, Institution of Electrical Engineers, Savoy Place, Victoria Embankment, London WC2. Tel. COVent Garden 1871.

Transmission and Processing of Information, International Symposium.—Wed., 6 Sept., to Fri., 8 Sept., at Cambridge, Mass., USA. Sponsored by the Professional Group on Information Theory of the Institute of Radio Engineers, in cooperation with the Research Laboratory of Electronics of the Massachusetts Institute of Technology. Apply to Mr. R. M. Fano, Research Laboratory of Electronics, Massachusetts Institute of Technology, Cambridge 39, Mass., USA.

Documentation, International Federation for.—*Annual Conference:* Wed., 6 Sept., to Sat., 16 Sept., at Caxton Hall, off Victoria Street, London SW1, at invitation of Aslib. Apply to the secretary, Aslib, 3 Belgrave Square, London SW1. Tel. BELgravia 5050.

Levant Fair, 25th International.—Wed., 6 Sept., to Thurs., 21 Sept., at Bari. Agent: Mr. Neven du Mont, 123 Pall Mall, London SW1. Tel. WHItehall 8211.

Household Goods and Hardware Fair.—Fri., 8 Sept., to Sun., 10 Sept., at Cologne. United Kingdom inquiries should be sent to Mr. Neven du Mont., 123 Pall Mall, London SW1. Tel. WHItehall 8211.

Royal Statistical Society, Conference.—Sat., 9 Sept., to Mon., 11 Sept., in the Churchill Hall, University of Bristol. Arranged jointly by the Society's Industrial Applications and Research Sections. Apply to Mrs. P. Arakie, Department of Operational Research and Cybernetics, United Steel Companies Limited, 1 Tapton House Road, Sheffield 10. Society's address: 21 Bentinck Street, London W1. Tel. WELbeck 7638.

Styling Models in Resin and Glass-Cloth

Models are used to check the style, appearance and colour scheme of cars before production is begun. The model of the Austin A55 Mark 2 saloon car, shown in the illustration, is a quarter

Quarter-scale model of the Austin A55 Mark 2 saloon car made from Araldite epoxy resin and glass-cloth.

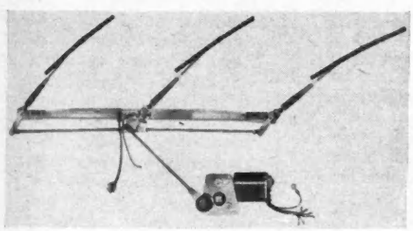
full size and has been made to scale by the Austin Motor Company from Araldite epoxy resin and glass-cloth. Several models of this kind are made for each new design of car.

Keeping Curves Clean

Wrap-round and deeply curved windscreens, while admirable in the improved vision they allow the driver and passengers, have some disadvantages. There is a larger area of glass to clean and at speed the wiper blades tend to lift by air pressure causing lack of visibility. A twin-bladed wiper, set to operate so that the blades sweep towards and away from each other will clean the outer portions of a curved screen, but leaves an unwiped segment in the centre of the glass.

The answer would appear to be a wiper with three blades. Even this is not new as some London taxi cabs used to be fitted with three blades which moved in a lethargic manner across a narrow vertical screen. More modern types were fitted to some cars with wide curved screens, but these were only special "one-off" versions by famous coach builders.

The faster the car, the more important it is



On the new Lucas DL3 windscreen wiper, the driving spindles of the two outer arms are set at an angle to the front of the car to allow for screen curvature.

to have clear vision and when the "E" type Jaguar was introduced it was interesting to see that a triple-bladed wiper was fitted. Joseph Lucas Limited have produced a new powerful two-speed model which has been designed specially to deal with the problem of cleaning a wide shallow screen.

It is known as the DL3 model and has a link pattern transmission. The twelve-volt motor is connected to the drop arm of the centre spindle by a rotating crank, eccentric coupling and primary link. Secondary links connect the outer spindles. When the motor is switched off, the armature reverses and by means of the eccentric coupling on the rotating crank, the effective length of the primary link is altered.

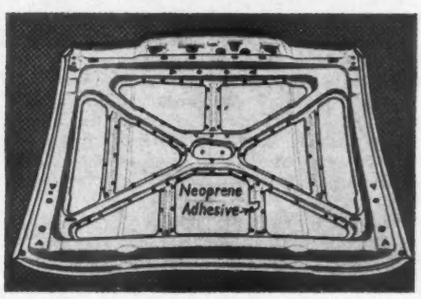
The travel locus of the centre drop arm is modified and the wiper blades move to the parked position. A cut-off switch is then operated by the drop arm and the motor stops. Fine adjustment of the parking position can be made by a separate control located under the bonnet.

At twelve volts the current consumption is 2½ to 4 A with the motor running at its normal speed of 45-50 cycles per minute. At the higher speed of 60-70 cycles per minute, the consumption is approximately half an ½ A less.

Preventing Bonnet Shake with Neoprene Adhesive

American manufacturers are defeating bonnet shake by using Du Pont neoprene adhesive to attach the external panel to the inner frame pressing. The adhesive is extruded on to the underside of the outer panel at 90 points, as indicated in the illustration, the inner panel is then placed in position and hem-welded.

As the bonnet assemblies are sent to the line the adhesive dries to a partial cure. The skin which forms protects it from sprays used to



By attaching the external panel to the inner frame pressing with neoprene adhesive, bonnet shake may be prevented.

clean and phosphatise the panels, and while the panels are being primed and finish-painted the adhesive reaches its complete cure. As it attains its full adhesive value the two panels finally bond together to form a single unit.

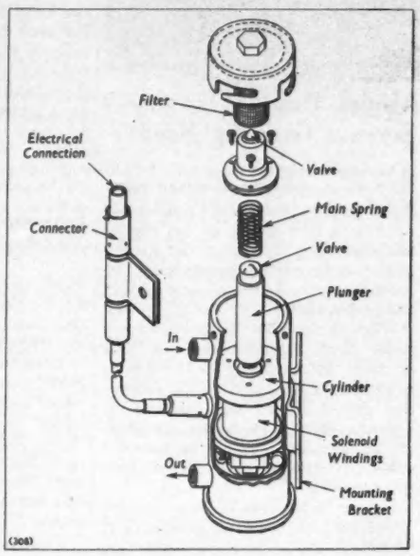
Reduction in weight, faster assembly time and greatly reduced bonnet shake are among the claims made by the manufacturer using this method. It does appear that this assembly adhesive could be used in the same way for doors and luggage locker lids, in fact on any panel which forms a cover and does not have to carry a load.

Long Life Electric Fuel Pump

After a lengthy period of development and exhaustive tests under racing conditions, the American Bendix electric fuel pump is now available in Britain. Being light but rugged in construction it has been designed with the utmost reliability in view and employs the principle of the well-tried common lift pump.

The stainless steel plunger which runs in a brass cylinder is hollow and contains a spring-loaded valve at its lower end. A second valve is situated in a fixed housing directly below. When switched on, an electric solenoid draws the plunger down thus causing its valve to open and admit fuel to the upper chamber. On reaching the bottom of its stroke the solenoid circuit is broken and a spring forces the piston up lifting the fuel above the piston towards the outlet, at the same time causing the other valve to open and admit more fuel into the lower chamber. No gland is used, a seal being provided by the fuel itself which fills the small clearance between the piston and cylinder.

The fuel is filtered by a fine screen at entry and a permanent magnet traps metal particles. Another permanent magnet on the interrupter armature senses the position of the plunger through the wall of the brass cylinder and operates the contact breaker points. The entire electrical mechanism is hermetically sealed in an inert helium gas atmosphere and this, it is said,



Exploded view of the Bendix electric fuel pump. Maximum delivery is 25 gph and maximum power required 7 watts.

renders the pump tamper proof and unaffected by extremes of climatic conditions.

Maximum delivery is in the region of 25 gallons per hour but capacity and pressure are dependent on the design of the main spring so that the pump is readily adaptable to other uses, an example being the operation of an artificial kidney. The maximum power required is 7 watts and the whole unit which is encased in rust proof steel weighs 1 lb 13 oz.

Installation is facilitated by a drilled bracket attached to the case.

Motor Books and Accessories, 33 St. Martin's Court, Charing Cross, London WC2.

Viton Petrol Pump Gasket Gives Better Service

A new form of gasket, less than 2½ cm in diameter, is now being used in the nozzles of filling station pumps in many European countries. Made of Viton, a fluoroelastomer developed by the Du Pont Company, the gasket is fitted to a petrol filling device supplied by Elaflex Gesellschaft MbH, Rothenbaumchaussee 140, Hamburg 13, Germany.

The gasket is said to offer the following advantages:

(1) quicker filling;
(2) no spilling;
(3) no leakage in the nozzle of the pump;
(4) no residual petrol odour;
(5) good resistance to aromatic fluids;
(6) reduced risk of engine faults through tiny rubber particles from the gasket entering the tank; and (7) retention of shape.

The Viton gasket, tested in a large number of garages throughout Germany, is reported to have a longer service life and a considerably higher resistance to aromatic fluids than other types of gaskets. Some materials used previously for this purpose are understood to have crumbled within a short period.

Viton has been specially developed by the Du Pont Company for high-quality industrial use. With an outstanding resistance to heat and chemical fluids, it can operate at temperatures up to 315° C and above in intermittent service, and at 205° C in continuous service. Its resistance to a wide range of corrosive chemicals, fuels, oils and solvents is also exceptionally high.

Human Element

Model Makers Serve a Growing Need

THE engineering sales executive travelling abroad in connection with the supply of components may conceivably be able to take certain of the smaller examples along with him; but for the most part he can adequately meet the questions with details of specification and performance.

When the subject of the contract is major plant, for producing chemicals or steel for instance, he would be reduced to figures and verbal description were it not for the services of the small but thriving model making industry to help him answer the potential customers' demand to be shown something tangible.

One of the companies long practised in putting exact models of products and plant into the hands of engineers are Partridge's Models, of Paddington, London, who employ a dozen craftsmen of varied skills but completely uniform dedication to devising, mostly in plastics and metal, intricate and highly detailed models of complex plant. Not in model form, but given equally skilled care, are the prototypes, hand made by the firm and from which refinements are often made, saving large sums of money before tooling up for production has begun.

When a product is taken straight into production from drawings and a rough mock-up there is a well known tendency for defects to appear at a time when modifications are necessarily expensive.

A further advantage of the highly accurate, craftsman-built prototype is that problems of finish and colour can be much more adequately resolved.

Showing the Backer

For the inventor who has to find financial backing for his product, or the staff designer who has to gain the acceptance of the board, there are obvious advantages in having the three-dimensional, demonstrable prototype to put forward.

On the model side of the work of these companies the range of plant that has been modelled is particularly wide. Partridge's have coped with the problems of showing the ease of removal of engines in a cargo ship for repair purposes. For this a cross-section model of the ship was built up. For a major airline they have also built a scale model of a computer centre, which was submitted along with the tender.

At the Moscow Trade Fair, a Partridge model showing the functioning of automatic hydraulic pitprops in association with a coal cutting machine, was attracting the attention of numbers of technically versed Russians and of the general public. This model was an outstanding example of just how this technique can be used to demonstrate in moments a complex industrial performance that would otherwise take long and involved explanations, even between people of common language.

For educational purposes, for the conduct of lawsuits and the preparatory work involved, for engineers, contractors, architects and many others the use of models has been growing considerably since the war.

By its nature model making is work that individuals of imagination and care can carry out from their homes. For the small but lively companies that do much of the model making for industry there is plainly a bright future. While the business of exporting capital equipment grows and the costs of tooling up for mass producing goods increases, avoiding last-minute alterations becomes ever more desirable.

Golden Shoe Club for Accident Escapers

What the YZ club is to safety helmets the Golden Shoe Club is for safety shoes and boots. Formed by a group of safety footwear producers, the club is open to anyone able to show that safety shoes have saved him from what would otherwise have been severe foot injury. Applications for membership of the Golden Shoe Club are usually made through safety officers. Incidents must have occurred since 2 May of this year to be acceptable as a qualification.

The new safety club has no dues, and generally no meetings. Membership entitles the safety shoe wearer to a lapel badge, an illuminated certificate and a green and gold club tie.

Wearing the badge or the tie may be a useful aid in furthering awareness of safety problems, natural curiosity is likely to make the club insignia a starting point of safety conversations. There is no doubt that foot injuries are a serious feature of industrial accidents.

During 1959, the last year of full figures, there was a foot accident somewhere in industry every four minutes. And this average is arrived at by including only the reported accidents, that is those which cause more than three days absence from work. The Chief Inspector of Factories has said that many of these accidents could be prevented by the wearing of safety footwear.

Modern safety shoes and boots look exactly like normal footwear. The essential, unseen, feature, is a concealed steel toecap which is tested to strengths specified by the British Standards Institution and is able to withstand very considerable blows.

The Golden Shoe Club, which is fully commended by the Royal Society for the Prevention of Accidents, has its headquarters at 134 Wigmore Street, London W1.

RoSPA Leaders Join Advanced Motorists

At least one point of agreement in all the divergent views on what should be done to reduce the level of road casualties is that greater skill on the part of motorists would go some way to assist.

Two new members of the Council of the Institute of Advanced Motorists, whose enlistment on the Council follows out this line of thought, are Sir Howard Roberts and Sir Richard Nugent, the President and Vice-President of the Royal Society for Prevention of Accidents.

Sir Howard Roberts also sits on the Road Safety Committee of the Ministry of Transport. He retired from the position of Clerk to the London County Council in 1956.

Sir Richard Nugent, MP for Guildford, was Parliamentary Secretary to the Ministry of Agriculture and also to the Ministry of Transport, between 1951 and 1959.

Direct Channel Route Even More Essential

Most enterprises and organizations have some idea that for Britain to enter the European Economic Community would be clearly to their benefit or to their disadvantage.

For the Channel Tunnel it seems that if the United Kingdom goes into the Common Market the tunnel will be a necessity. If she stays out it will be even more necessary.

These views were put forward at the recent annual meeting of the Channel Tunnel Company by the chairman, Mr. Leo F. A. S. d'Erlanger. The argument appears unassailable. If Britain is to become a member of the EEC that will be only a first step. The next business will be to get down to making our participation as great a success as possible. To this end a direct transport link with the mainland—whether tunnel or bridge—will become more and more essential.

If Britain has to stay on the outside, competing against industrial units of ever-growing size and more competitive production costs, everything possible will need to be done to keep even the present share of the world market, and this would include a direct transport route to the continent.

Mr. d'Erlanger added the prediction that if the construction of the tunnel is not sanctioned, then within a few years communication with the European states will be as congested as the present road system.

The Channel Tunnel Study Group are vigorously pressing the tunnel project, though the Channel Tunnel chairman adds the important qualification that even when the political gates have been opened a considerable amount of detailed negotiation will still be necessary.

One of these is going to involve raising £130 million as an international loan, which is bound to be to some degree dependent on the financial climate at the time. Much of the capital may perhaps be found in the USA and, for the moment, the evident enthusiasm in the United States for a closer British association with the European Economic Community could result in some easing of the inevitable problems of obtaining money on this massive scale.

Astronauts not Automats for Spotting Trouble in Space

Dr. Milton Grodsky, manager of life sciences for the United States project Apollo, the manned vehicle moon study being conducted by the Martin company of Baltimore, has declared that human beings projected into the unpredictable environment of space flight will do a better, more economical, job of spotting trouble in complex equipment than the most modern of automatic devices.

Dr. Grodsky was talking to a joint meeting of the Institute of Aerospace Sciences and the American Rocket Society. It is his view that in future developments the astronaut will be vital to the maintenance of smooth operation of the spacecraft, even though the space vehicle will be highly automatic.

Experiments conducted by the Martin company have shown that man's behaviour closely follows an ideal mathematical model of maintenance performance. Under tests made by Dr. Grodsky a number of human subjects were in competition with a mathematical model, in practice with a set of equations describing the perfect system for space ship maintenance.

Individuals undergoing the tests were faced with up to 120 simulated "malfunctions" in the course of a laboratory space trip.

In Dr. Grodsky's view, good trouble shooting depends less on mechanical abilities than on the repairman's intellectual performance as a decision maker.

"Given a proper display of information, such as the space vehicle's instrument panel, man is ideally suited to using such data and translating them into maintenance decisions," said Dr. Gorsky.

Emancipation for Electronics by the Electricals

The growing importance of electronics in industry, and the extent to which electronic development has become consolidated, is now recognized at the Institution of Electrical Engineers where, from the assumption of office by the new Council on 1 October this year, the power and electronics interests will be equally represented.

The meeting of the Institution Council held on 18 May, passed this resolution:

"The Council, recognizing the significance of electronics interests in electrical engineering, Resolve

(1) That steps should be taken to ensure, as far as practicable, equal representation on the Council and Council committees of the interests generally identified as "electronics" and "power"; and

(2) That, in order to ensure that no obstacle lies in the path of any suitably qualified person, being admitted to membership of the Institution, the Education and Training and Examinations Committees be asked to review again the examination syllabuses and training regulations to ensure that they are appropriate for those (in particular, electronics engineers) who though of recognizable professional level, are not adequately provided for under the present regulations."

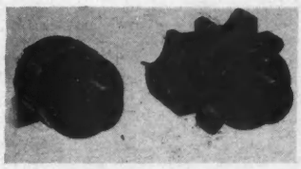
Pointing out that the balance on the Council will, from October, be equal, the IEE observes that for the future it will remain to hold this balance. In the case of the committees it is intended to establish equal representation during the selection of committees for the next session. This selection will be taking place later in the summer.

The Council have already effected significant changes in the rules on acceptable qualifications for Graduate membership, mainly affecting those entering electrical engineering from physics and mathematics. The syllabuses of the examination itself are now undergoing detailed review.

Further announcement of the steps being taken by the Council to bring the structure of the Institution up to date and to give electronics its full place is to be made shortly.

FLOW CONTROL VALVES

Air Ventilated Systems



DESIGNED for the control of air flow to the ventilated suits of aircrew, the two valves shown have been developed to a Ministry of Aviation specification.

Air crew dressed in the complex of modern flying clothing can suffer considerable discomfort due to extremes in ambient conditions, unless conditioned air is allowed to circulate between the clothing and the body. This is achieved by the use of an air ventilated suit worn under the remainder of the flying clothing and supplied with conditioned air from an external source. As the mass air flow required for comfort varies according to individual conditions, it is necessary for wearers to control the air flow to their suits.

The two valves, types FAC102-006 and FAC102-007 are type tested and are intended for line mounting. Occupying very little space, they are operated by rotation of an external sleeve sited co-axially about the pipe centre line. The sleeve is serrated for easy handling with the gloved hand, the serrations being smaller on the FAC102-006 and exaggerated to form a star wheel configuration on the FAC102-007. The latter is intended for use where installation requirements demand operation at arm's length or in awkward positions. Rotation of the sleeve moves a streamlined plug either on to or away from a seat.

Intended for operation at 2 lb per sq. in, the valves will perform satisfactorily with through air temperatures between − 45° C and + 100° C and ambient temperatures from − 45° C to + 70° C. At 2 lb per sq. in inlet pressure and 14 cfm (free air) flow the pressure drop in the wide open position is 0·20 lb per sq. in. In the closed position the valves are leak-tight downstream, and in all positions they are leak-tight to atmosphere. *Hymatic Engineering Company Limited, Redditch, Worcestershire.*

TIMER

Automatic Reset

AN ELECTRICALLY operated automatic reset timer, the PT5 is a recent addition to the Venner range of time switches and process timers.

This synchronous motor-driven timer combines within the single basic unit a number of timing functions hitherto obtainable only by using different instruments for each operation.

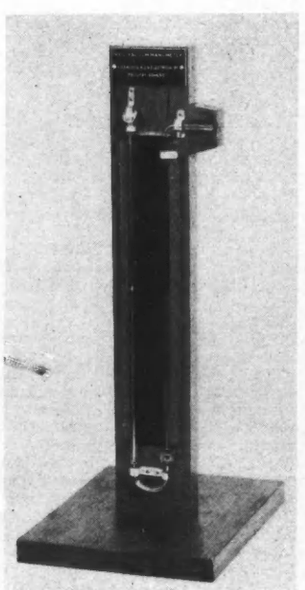
The timing motor and operating contacts are brought out to separate terminals on a multi-way terminal block arranged in a semi-circle at the end of the cylindrical casing. By making the appropriate connections, the PT5 timer may be used with equal facility as a delay relay, recycling process controller or single operation process timer.

A pair of contacts which close momentarily at the end of the cycle may be connected to a second timer, thus initiating it. Thus a group of timers may be interconnected to control a number of processes in a pre-set sequence.

The timing dial, 5 in square, is of black anodized aluminium with white lettering. Time setting is effected by turning a moulded finger-grip knob on its friction until the pointer shows the desired period. The centre disc which revolves when the timer is running indicates the expired time, and returns to the set time position on completion of the operation. All contacts on the timer are rated at 10 amps up to 250 volts, or 5 amps up to 500 volts ac. *Venner Limited, Kingston-By-Pass, New Malden, Surrey.*

VACUUM MANOMETER

For Greater Accuracy



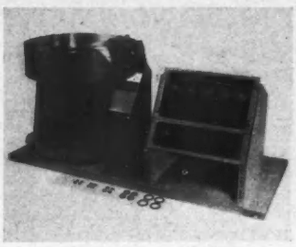
DEVELOPED at the National Engineering Laboratory, a U-tube type of portable vacuum manometer is designed to maintain accuracy of measurement.

The leakage of air into the closed limb of conventional U tube manometers increases rapidly at higher vacuum measurements. To reduce errors due to this cause, the new NEL manometer incorporates a bulb at the top of the enclosed limb to provide expansion space for entrapped gas which arises by leakage past the mercury column or by evolution from the mercury itself. An identical bulb at the bottom of the open limb receives the mercury falling from the upper bulb when vacuum is connected. Capillary tube between the limbs lessens violent movement when the vacuum is released.

The range is 0 to 300 mm Hg, and the reduction in error over a conventional instrument with the same volume of entrapped gas is from 17 mm Hg to 0·33 mm Hg at 300 mm Hg. *NGN Electrical Limited, Accrington, Lancashire.*

BATCH COUNTERS

Many Applications



COMPACT batch counters, with 2, 3, 4, or 5 Dekatron tubes, which can be supplied with many modifications to suit particular applications, are some of the most recent developments in the Pentechnique Limited range of counting units.

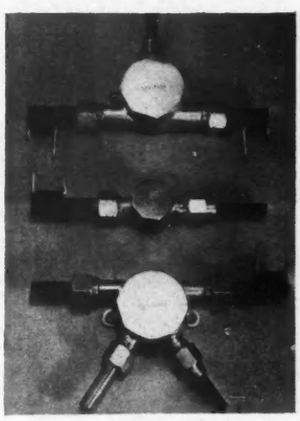
Capable of batching numbers up to 99,999 at rates up to 5,000 per second, the units can be fed from photo-electric or magnetic pick-ups. Specifically designed controls and circuitry for the type of feed equipment to be used are installed in the lower section of the units. The batch output signal can be in the form of relay contact closure or an electrical signal.

Illustrated here is a 5-Dekatron batch counter used with a vibratory bowl feeder and photo-electric pick-up to count pre-selected quantities of rubber O rings. Two simple adjustments cover 15 different sizes from $\frac{3}{32}$ in to $\frac{1}{16}$ in o.d. All controls, including those for the bowl feeder, are grouped on the lower panel of the unit, and the circuitry ensures foolproof operation. The starting button resets the Dekatrons to zero to initiate the process. If the resetting is faulty the bowl feeder will not be energized, and the operator therefore need not check that the resetting is correct. The "Stop" button can be used to arrest the bowl feeder during a count, and subsequent operation of the "Start" button will not reset the Dekatrons but will allow the count to continue from where it left off.

A variety of magnetic and photo-electric pick-ups can be supplied to detect a wide range of components. *Pentechnique Limited, Imperial Lane, Cheltenham, Glourcesteshire.*

GUNMETAL CONNECTORS

For Coaxial Cables



A NEW type of fitting named "Konaxal" is designed for connecting the coaxial cables used for piping television.

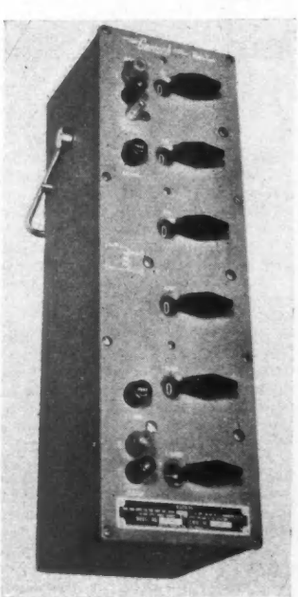
There are certain areas throughout the UK where satisfactory television signals cannot be received due to geographical obstacles or on account of man-made interference. In those areas it is becoming the practice for the television signal to be received at one high point from which it is then piped down into the towns and villages which are screened from receiving the normal signal direct from the transmitter.

"Konaxal" fittings are complete junction boxes and connections in themselves, and since they are made from gunmetal which contains 85 per cent of copper they possess high conductivity. These waterproof fittings are suitable for outdoor use without corrosion.

Up to now these fittings have been made in three main types: two-way, three-way and four-way. Each of these patterns is capable of having included upon it any combination of cable sizes according to individual requirements, and further types will be developed to suit the particular demands of relay firms. The fittings are as developed for General Piped Television Limited, of Neath, Glamorgan. *Kay and Company, (Engineers) Limited, Bolton Brass Works, Blackhorse Street, Bolton, Lancashire.*

TRANSFORMERS

Measuring Voltage Ratios



NOW available are two Wayne Kerr-Gertsch ratio transformers which offer a highly accurate means of providing and measuring ac voltage ratios over a wide frequency range.

Typical uses of these transformers are as ratio standards in, for example, the ratio arm of a bridge, or as an ac potentiometer for checking resolvers, servos, transformers and computers. Known as the RT4 and RT5, the new transformers operate from 30 to 1,000 c/s and 50 to 10,000 c/s respectively and have a high input impedance, low effective series impedance and low phase shift. Over the lower frequency range ratio accuracies of 0·001 per cent are obtainable, and 0·01 per cent over the upper.

Ratios are selected by operating five decade switches and a single-revolution potentiometer. Both units have a terminal linearity of 0·001 per cent. Normal emperature range for both transformers is from −15° C to +80° C. *Wayne Kerr Laboratories Limited, 44 Coombe Road, New Malden, Surrey.*

DIGITAL VOLTMETER

Print-Out Facilities

THE 4-figure rack mounted digital voltmeter shown here is especially suitable for accurate measurements, monitoring and setting up in electronic systems.

This flush panel instrument, designated LM 902.2R, is identical in electrical performance to the manufacturers' bench model LM 902.2. For standard 19 in rack mounting, the unit presents d.c. voltages from 100μ V to 1·599 kV as a 4-digit display in decimal form with polarity discrimination. Display is by optical projection and is free from any ambiguity. Red and black backgrounds signify positive and negative inputs respectively.

Unusually wide voltage measurements are covered in five ranges. The input impedance is 10 M Ω, except on the two lower ranges which have impedances of 1 M Ω and 100 k Ω. The long term accuracy is $\pm$ 0·1 per cent of maximum reading on each range. Two additional high impedance voltage ranges of 100 V and 1 kV have input impedances of 100 M Ω; accuracy is of $\pm$ 0·5 per cent.

The read-out time is constant at 280 milliseconds irrespective of the voltage input, which may be "floated" up to 700 V with respect to earth. A "check" position permits zero setting.

Under normal (Auto) operation voltages are measured continuously, any variations causing the instrument to display a new reading. When switched to "Sample" mode of operation a single voltage reading is taken, either by manual operation of a panel button or by remote electrical command. This reading will remain on display until a succeeding sample is taken. *Solartron Laboratory Instruments Limited, Cox Lane, Chessington, Surrey.*

SPRAY GUN

Fine Finishing Nozzles

NOW announced is the introduction of a new spray gun, known as the Hydra-Spray "Golden" gun, and a new range of fine finishing nozzles.

Designed to increase efficiency and reduce operator fatigue, this model is a lightweight spray gun incorporating a rotary-action type packing which eliminates leaks. Only a light trigger pressure is required to give an immediate and precise spray pattern, and there is an absence of "lag" in the functioning, which obviates spitting.

The advantages provided by the new "FF" fine finishing nozzles are that such finishes can now be applied with feathered edges, thus enabling passes to be lapped, and in addition the "FF" nozzles can apply thinner coatings than have so far been possible. There are 17 "FF" nozzles, covering the whole range of fine finishing applications.

The gun is equally efficient for high volume fine finishing or protective coating work. The single hose enters the gun handle for improved balance, and the coupling of the hose to the gun is by a special swivel attachment. A tungsten carbide fluid valve and seat is incorporated and the gun and nozzles are designed for use with the Graco Airless Hydra-Spray equipment. *Alfred Bullows and Sons Limited, Long Street, Walsall, Staffordshire.*

BLENDING MACHINE

Portable or Static

THIS unit, the Suba blending machine will bring any two liquids together and deliver in a pre-arranged proportion through a diffuser chamber just prior to delivery. The settling-out problems usually associated with storage vessels are thus eliminated.

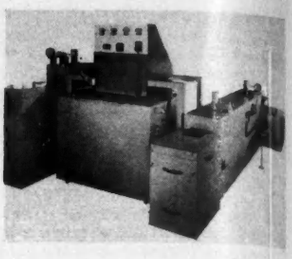
Standardization of the mechanism has made it possible to supply the machine either as a wall-mounted unit or as the portable unit which is illustrated here.

By using one liquid under pressure as a constant factor the second liquid can be added to give a proportion from 5 per cent to 40 per cent of the total output of the plant.

All liquid handling cylinders are of brass and the end castings, pistons and valves are of bronze. The pipes and fittings are of copper and galvanized steel, while the tanks and cover are all welded mild steel fabrications. The tank internal surfaces are treated with alcohol resisting dressing, and the external surfaces and the non-moving parts are finished in hammer blue, with hoses in clear vision braided nylon. *Suba Hydraulics Limited, Limes Place, Limes Road, West Croydon, Surrey.*

DIP COATING PLANT

Using "Fluidized" Plastic



THE ILLUSTRATION shows a semi-automatic plant specially developed for the plastic coating of components by the recently introduced "fluidized" powder technique.

The chief advantages claimed for this process are that it imparts a high level of chemical resistance, that it is equally suitable for one-off requirements or mass production, and that there is negligible raw material wastage. The process also gives an attractive and durable finish.

Designed for applying a decorative and functional plastic finish to a range of hooks, the plant shown was manufactured by Lionel Hook and Sons Limited, specialists in machinery for the latex and PVC dip moulding and control dip finishing fields.

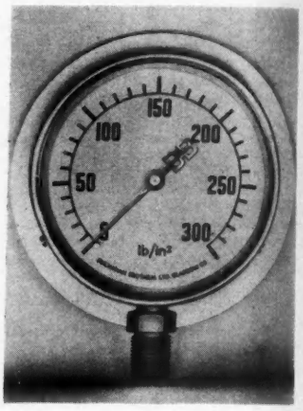
The equipment comprises a preheating oven with variable speed chain conveyor. A central unit houses all the electrical control gear and is fitted with a conveyor and suitable flight bars for immersing the hooks in the powder for a predetermined period. A device for collecting surplus powder after dipping is incorporated, and a final curing oven is fitted through which the hooks are moved on a third variable speed conveyor.

The polythene powder used is Telcothene and the fluidizing tank is a "Dipkota" model, both of these being products of Telcon Plastics Limited.

A feature of the present plant, which is the forerunner of a general purpose unit now under development for similar work with thermoplastic powders, is the method of handling and dipping, which avoids the deposit of plastic on the screwed portion of the hooks. *Lionel Hook and Sons Limited, Ebley, Stroud, Gloucestershire.*

PRESSURE GAUGE

Low Price



KNOWN as the "Clyde" Economy pressure gauge because of its low price, this new instrument is the result of special production techniques.

The concept of designing the instrument and the technique of its production at the same time was demonstrated by the manufacturers two years ago with their V.B. Industrial Thermometer.

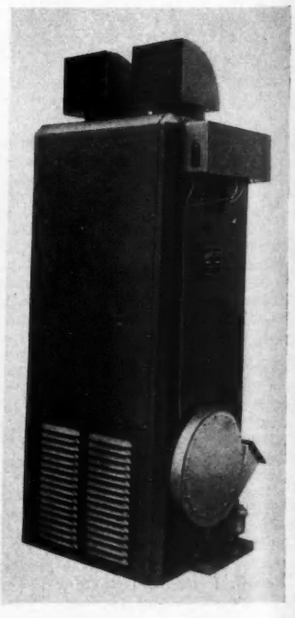
The new gauge uses a tube with a conventional quadrant and pinion mechanism. The movement of the tube is transferred to the quadrant by means of a locating pin attached to the tube and moving within a slot in the tail of the quadrant. This mechanism has already proved to be accurate and reliable.

The gauge has a flange back and a brass lacquer finish as standard. Block and dial screws are concealed, a feature which enhances the external appearance. A full range of British Standard pressures from 60 lb per sq. in to 600 lb per sq. in is available, and the scale markings are of the Easiread type, first introduced by this manufacturer.

In addition to the 4 in dial size model which has just been introduced, a 2 in and a 2½ in model are planned to go into production shortly. Delivery of quantities of 1,000 plus is currently four weeks. *Buchanan Brothers Limited, Commerce Street, Glasgow.*

INDUSTRIAL SPACE HEATER

Smaller Model



AN INDUSTRIAL space heater, the Model 30, has been introduced into the Dravo range, designed especially to meet the requirements of smaller premises.

With an output of 300,000 Btu per hour, the Model 30 is suitable for heating factory bays of up to 80,000 cu. ft, and a wide range of buildings such as garages, public halls and showrooms.

The Model 30 has a stainless steel combustion chamber and a 4-pass flue gas travel system. The heater also includes directional nozzles enabling the warm air to be directed wherever required, and an induced draught exhaust which eliminates a high flue-stack. Ducting can be connected to the top of the heater to convey heat to partitioned areas.

Available with gas or oil firing, the heater is 101¾ in high, 45½ in long and 30¾ in wide. The blower fan motor is 1 hp and air output is 3,250 cu. ft per minute. *Powell Duffryn Modulair Limited, Vale Road, Camberley, Surrey.*

BACKING-OFF ATTACHMENT

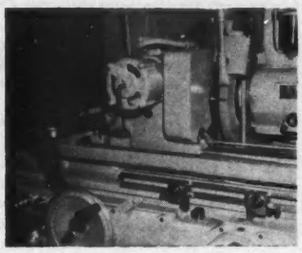
For Grinding Machines

THE attachment illustrated, mounted on a Jones-Shipman Model 1200E Precision Grinding Machine, is designed for the purpose of grinding the reliefs on router cutters.

Feed from the motor is transmitted through gearing, pawl and ratchet wheel, cams and a rocker arm to the collet spindle. A handle is screwed into the end of the rotor spindle for the purpose of setting the cams in the correct relationship to one another.

The speed of the motor is 1,425 rpm and through reduction gearing the spindle speed is 84 rpm. The feed pawl can be set to feed the ratchet wheel either 1, 2 or 3 teeth. As a result of this arrangement three cycle times of 7, 10·5 and 21 seconds are obtainable. The rate of feed per revolution of the spindle is dependent on the form of the cams fitted.

The design of this attachment is such that the form ground on the workpiece is $\frac{1}{4}$ that of the rocker cam form.



When the required relief has been ground a limit switch is operated by means of the feed cam to stop the drive motor.

The attachment can also be used for double backing-off by relieving in two directions simultaneously, and a spindle cam is fitted in addition to the rocker cam for this purpose. Centre drills with double reliefs are ground using an attachment equipped in such a way. A loading arrangement is provided so that the centre drills may be located correctly.

The Model 1200E machine is most suitable for use with this attachment as no automatic traverse is incorporated on that model. *A. A. Jones and Shipman Limited, Leicester.*

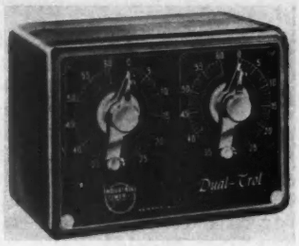
RECYCLING TIMER

Versatile

JUST introduced, the Series Dual-Trol versatile recycling timer is particularly suited for the control of machine tools, material handling and chemical processes, or virtually any operation where "on" and "off" intervals must be frequently changed.

This timer produces a series of "on" and "off" electrical pulses, which can be used to stop and start a process in a predetermined sequence. The time interval of both the "on" and "off" signals is readily changed by adjusting the timing knobs on the face of the two timing modules, one of which controls the duration of the "on" cycle and the other of the "off" cycle.

With any two timing modules, the duration of either the "on" or the "off" interval can be adjusted within a wide range, although both modules can be adjusted within a wide range to produce other time intervals. A wider range of time intervals can be obtained by inserting different timing modules.



The timing modules are accommodated in a sturdy two-piece baked enamel steel housing. Conduit knock-outs are provided on the side and bottom of the unit. All electrical connections are made on a terminal strip within the unit, eliminating any shock hazard.

This timer is operable on either 115 or 230 volts at 50 or 60 cycles. The SPDT switch is isolated electrically from the timer motor circuits, and is rated at 10 amps, non-inductive at 115 volts and 60 cycles. The compact unit measures only $7\frac{1}{2}$ in by $5\frac{1}{2}$ in by $5\frac{9}{16}$ in. *Industrial Timer Corporation, 1407 McCarter Highway, Newark 4, New Jersey.*

INTEGRATING GYRO

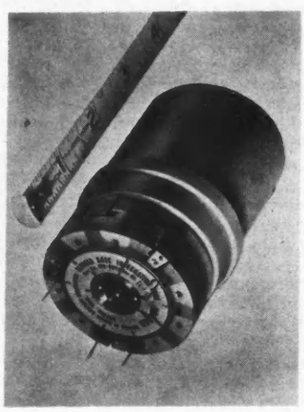
Precision Miniature

RECENTLY introduced by the Norden Division of the United Aircraft Corporation, and now available in the UK through Ketay Limited, is a new miniature integrating gyro, the Type RI-203.

Applications for this precision gyro include inertial navigation and guidance for missiles and aircraft, stabilization of shipboard devices, and many others where there is a demand for precise dynamic angular measurement. The gyro has been installed, in conjunction with Norden single axis accelerometers, in the new miniature all-altitude inertial platform which was recently shown in the UK.

Outstanding features of this instrument include a low drift rate—it has a random drift of less than 0·02 degrees per hour—and a favourable day-to-day stability amounting to 0·10 degrees per hour without trimming. The gyro has the long life of 3,000 hours.

The small drift rate has been attained by virtue of a spin motor turning at



only 12,000 rpm, and this low speed contributes substantially to the long life of the unit.

Measuring only 3·1 in in length by 2 in in diameter, this guidance gyro weighs 1 lb, including heater and shields. *Ketay Limited, Eddes House, Eastern Avenue West, Romford, Essex.*

FEED UNIT

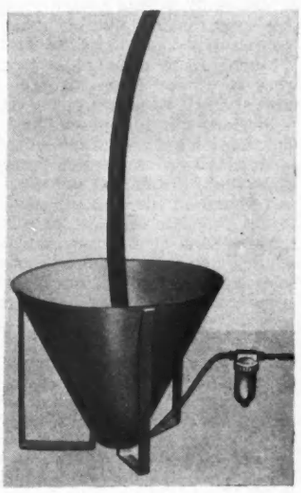
For Hopper Filling

AS an alternative to the manual loading and topping up of feed hoppers with granulated and free-flowing powders, the simple device shown here offers a more economical method.

The manufacturers developed this feed unit in an endeavour to supply their own "blow-moulding" equipment with a hopper feed, and many industrial applications for the ancillary fitting now announced are foreseen.

As the illustration shows the unit consists of a hopper, which can be placed on the floor or at any convenient point for accepting raw material from the bulk source, and a large bore flexible pipe led into the machine hopper. This hopper will normally be situated at some height from the ground, and usually on top of the machine it serves.

Operation is by compressed air at 60 lb per sq. in and in one minute the unit will raise 20 lb from floor level to an elevation of 7 ft, capacity increasing with the air speed. The system prevents large metallic particles from entering



the plant. *Amigo Machine Company Limited, Skylon House, Park Royal Road, London NW10.*

PUSH-BUTTON STATIONS

Pendant Type

A RANGE of pendant type push-button stations is announced, designated Class 9001 Type TYB and available in nine sizes to accommodate any number of units from two to ten.

These pendant stations are available completely assembled, or cases and operators are available separately. This flexible marketing arrangement allows assembly on site as required.

The enclosures are of oil and dust-tight all-metal construction and are designed to withstand heavy usage. The units are suitable for all types of industrial atmospheres, and any of the manufacturers' Class 9001 push-button actuators can be included in them.

Optionally available is a "wobble stick" actuator, which offers additional personnel safety. Pushing the lever in any direction actuates a set of contacts and makes this facility particularly suited as an "emergency stop" where it is desirable to reach the operator quickly from any direction. *Square D Limited, Cheney Manor, Swindon, Wiltshire.*

POWER POSITIONER

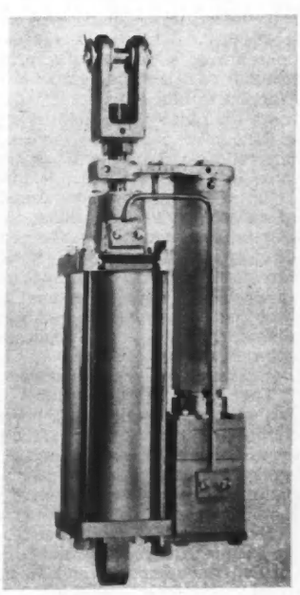
Pneumatic

A NEW small pneumatic power positioner which is capable of controlling unbalanced loads of up to 150 lb is now available in the UK.

The positioner is designed to drive valves, dampers and other control devices in any conditions, and has an accuracy rating of $\pm$ 1 per cent.

With 100 lb per sq. in air pressure and under no load, the positioner requires 1·5 seconds to complete a stroke movement. The frequency response of the unit with no load at 10 per cent peak to peak input signal is 1·3 cps. At 5 per cent peak to peak, the frequency response is 0·5 cps.

The small size of the unit makes it particularly suitable for use by butterfly valve manufacturers and in other fields of original equipment manufacture where there is a requirement for simplicity of installation and a need for low initial cost with the absence of maintenance in operation. *Hagan Controls Limited, 14 Grosvenor Place, London SW1.*



The Shortest Route to Optimum Design

The optimum combination of design or operating parameters can be found with least effort by exploring the structure of a problem using automatic analysis of a mathematical model.

By J. G. Bryan and Thelma J. Darwent

Atomic Power Constructions Limited

OPTIMIZATION, the technique of choosing the best of several possibilities, is involved in almost every human activity and must have been studied in some form or other from time immemorial. The incentive to direct a large amount of effort to such general questions depends on the consequences of being right or wrong in one's choice. Indeed the rapid growth of huge industrial combines and the advent in the past quarter century of many projects of great financial value has focused attention on the serious effects of an error in basic design.

This incentive, together with the general infusion of scientific ideas into everyday life, has greatly accelerated the systematic study of problems involving many factors. The outcome of this study is that a wide range of problems that appear at first sight to be unrelated can be reduced to a common or canonical form.

Much of the stimulus to proceed with this work is derived from the profound effect of unification of treatment in the natural sciences, particularly the role played by minimum principles. One has only to think of such milestones in development as the use of minimum energy in the study of stability and the work of Lagrange and Hamilton[1] in reducing most of mechanics to the Principle of Least Action. As ideas of measure are introduced into other fields of inquiry, and the more fundamental concepts of science find application, one can hope for similar successes. Indeed this progress is already apparent in many topics of operational research such as queueing theory[2].

In engineering design studies one is usually trying to find the extreme values of such functions as the cost of the final product or the power-to-weight ratio of some unit. A "function," in this context, merely implies the existence of a set of rules for carrying out a particular calculation. That the criterion for choice of action can be expressed as a minimum principle makes possible the development of a unified treatment of cases where the actions range from complicated operations to the fixing of design variables.

VARIABLES AND COMPUTERS

If the criterion function of interest can be represented as an integral and the design limitations are of a very simple form the classical methods of calculus of variations may be used. With up to four variables it may be feasible to cover the range of possibilities exhaustively but as the number of variables increases this becomes impracticable especially if, as usually happens in realistic cases, evaluation is difficult.

But in any mode of computation a technique of analysis that throws light on the structure of a problem and reduces the necessary amount of computation is highly desirable. Thus while the methods described below were used at first to extend the range of manual computation to problems that would otherwise have required a digital computer, later application was made to problems that in the ordinary way would have been difficult even on a digital computer.

The optimization procedure discussed here has been programmed for the Ferranti Mercury computer and is automatic in the sense that given a mathematical model and a set of design restrictions it will search by itself for the optimum point. Being able to compare optimum with optimum makes it possible to assess different schemes on a fair basis. It also becomes feasible to examine the effect on the "optimum point" of design assumptions and limitations. In this way the potential development in any given direction can be estimated, and resources apportioned accordingly.

While mainly concerned with the analysis of a mathematical model of an engineering scheme, the basic ideas can also be applied to experimental design and plant operation. Thus, just as the optimizing routine starts with a trial point and seeks the best combination of design values, so the results of a given set of experiments covering a limited region may be used to predict a different region within which further experiment is likely to be profitable. As a result it may be possible to reduce greatly the amount of experimentation necessary to achieve the desired optimum condition. A second article will illustrate this approach applied to the design of a pneumatic breakwater and other examples.

PREPARATION OF DATA

The techniques described in this paper have been applied to functions involving up to twelve independent variables, encountered mainly in the design of nuclear power stations. However, most of the illustrations in the text are derived from the study of a simple engineering problem in the design of cranes. In this way it is found that the salient features of the optimizing process can be demonstrated realistically without reference to highly specialised knowledge.

In the present approach the problem must first be reduced to finding the minimum of a function in terms of independent variables. Reaching this stage is usually a major step for, when dealing with precise statements, there is frequently doubt about the criterion by which to judge the various alternatives.

The criterion of merit of a civil nuclear power station is simply the total cost of generation subject to limits on the variables determined by sound engineering practice. On examination, "the cost of generation" is a difficult concept because it depends on the interplay of capital and running costs and methods of financing. Thus before stations can be usefully compared, most careful definition of this apparently simple criterion is needed. Once the criteria (there may be several conditions to be fulfilled) are established they must be expressed in terms of the independent variables. In such complex plant this can be a major problem calling for information from different disciplines such as steam plant technology, civil engineering and reactor physics.

COMPREHENSIVE MODEL

To enable a mathematical model of the whole system to be developed, specialists in each aspect of the plant must supply information about the interrelations of the variables with which they are concerned. An important point emerges here in that no one part of the system can be optimized in isolation. Rather, the interrelations of the variables describing each part should be determined and then used in a study of the whole system, for the same variables are often involved in different parts of the complete system. Thus, in nuclear power stations the reactor coolant inlet temperature affects both the reactor and the steam cycle, a low value being desirable for the reactor, whereas a high value leads to a good steam cycle.

The construction of the composite model represents a challenging administrative problem. Usually the personnel who are able to develop and operate a general optimizing procedure are relatively poor at extracting and assembling the required design information. On the other hand the engineer who is concerned mainly with the practical details of some item of equipment cannot be expected to translate his relevant know-how into suitable mathematical terms.

The authors have found that formulation of a composite mathematical model of a nuclear station for optimization studies exposes many gaps in basic knowledge and helps to show where technical effort should be intensified. The importance of collecting sound data cannot be stressed too much in view of the mechanized nature of the optimization process. If the basic information is wrong or inadequate, the wrong problem will be solved and the answer be only of academic interest.

OPTIMIZING ROUTINE

The process can be most conveniently described by reference to a geometrical model. Suppose that the criterion, z, is a function of only two variables x and y such as pressure and temperature. Taking x, y and z as Cartesian coordinates with z vertical, a surface can be generated, each point on which represents a possible combination of the design variables. If the function is to be minimized the problem of optimization is clearly to find the values of the variables at the lowest point on the surface.

Such a surface can be drawn as a contour map, as illustrated. Here values of the function are written against the contours and the vertical lines at $x = 260$ and 460 represent the design limits within which this variable must lie; there is no limitation on the size of the other variable y. The design variables are measured in pressure and temperature but on the contour diagram they are both shown as lengths. That is, in constructing the model, the original variables x_i are transformed to new variables X_i whose units are those of length. The choice of scaling factors, that is whether one sets 1 in or 1 ft to 1 lb per sq. in, affects markedly the shape of the contours. This matter is considered in detail later and it is merely sufficient to note here that when a distance is referred to, it means a length on the contour diagram.

The accompanying diagram gives a good indication of the behaviour of the function over the entire range of interest and shows that the best values of x and y are about 340 and 220 respectively, at which point, G, the value of the function is approximately 15. However these diagrams are extremely time-consuming to prepare, no less than 30 points being required for the diagram illustrated, and indeed for functions involving more than four variables the construction of such a map is generally not feasible.

The basis of the method developed here is that in many cases the local behaviour of a function can be used to determine the direction along which to proceed towards the optimum. In this way it may be necessary to study the function in detail at relatively few isolated points, instead of surveying the whole field. Referring to the contour map, suppose that the value of the criterion is known at some point P_0 either by previous experience or by a trial evaluation. If a survey is made in the small region shown by the square at P_0, the direction P_0Q_0 at right-angles to the contours can be found (see appendix below). Then, by changing x and y so as to move along this "steepest" direction the function can be decreased most rapidly.

The line P_0Q_0 is not necessarily directed towards the optimum point G; nevertheless, on the basis of the information available within the small region around this starting point in the model, P_0Q_0 is the best direction in which to set out. From the figure it appears that one can travel along this line for a considerable distance before the function begins to increase, probably in the neighbourhood of Q_0. The usefulness of the direction P_0Q_0 can be established by proceeding along it to a second point P_1 and then carrying

out a further survey. This shows that at P_1 the direction of steepest descent has changed from P_0Q_0 to P_1Q_1. The angle θ_1 between the two lines is small, showing that further progress in the same general direction is likely to be useful. In the automatic routine the step length P_nP_{n+1} is related to the angle θ_n between successive directions thus enabling the process to adjust itself to the local topography of the surface. For instance, at P_4 the step length is reduced since the predicted path turns through a large angle at this point.

The general result of this procedure is that the path linking the points P_0, P_1, P_2 . . ., at which the function is diminishing, proceeds fairly rapidly over the surface until a narrow ridge or valley is encountered. Here the path starts to zigzag and progress may be very slow. When the axis of the valley is inclined to the axes of the variables the path may stop completely since altering any of the variables separately causes the function to increase. There are several techniques for dealing with such difficulties.

RIDGES AND VALLEYS

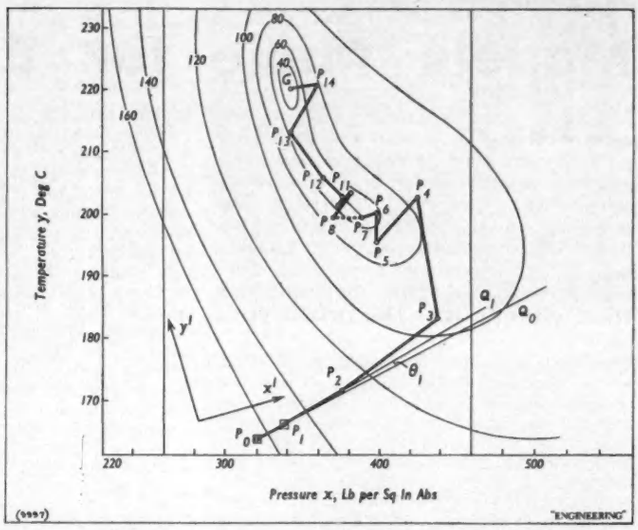
By slow progress one means that the predicted changes in the variables are less than some predetermined amount. Of course this is the state achieved when the optimum point itself has been reached. However, if the successive steps are very small with frequent changes of direction, and yet the criterion is still being satisfied, the path may be merely wending its way along a valley (or a ridge if a maximum is sought). Suppose that at P_7, in the diagram, such conditions arise. The procedure is to displace the path arbitrarily a small distance from the valley bottom to a point P_8 and restart the ordinary process. After a few steps the path usually leads back to the bottom of the valley, say at P_{11}. The two points P_7 and P_{11} are used to indicate the axis of the valley and a step is taken in this direction to P_{12} and the process repeated. The length of the step $P_{12}P_{13}$ taken along the valley is related, as in the ordinary procedure, to the length and direction of the previous step along the valley. In this way the bottom of a sharply curved valley can be followed.

In general, the presence of these valleys and ridges slows down the optimization process. But, since the shape of the contours can be changed by expanding one or more of the model scales it may be possible to transform a narrow valley into a region where the contours are more like concentric circles. The choice of scaling factors is part of the general question of the best variables to use in analysing any given problem. The original design variables are assumed to be independent but they are unlikely to be "normal" in the sense of optimising separately.

Thus, in the case of contours in the form shown, the optimum value of x depends on the value of y, and vice versa. If the problem could be expressed in terms of variables x' and y' in the directions shown, the optimum could be found very quickly, since the optimum values of x' and y' are sensibly independent.

Unfortunately, only very simple functions possess normal coordinates in the above sense that are applicable over a large region, and it has been found best not to spend much time in choosing the scaling factors but simply to make a reasonable choice and get ahead with the descending path. In the absence of further information about the function, the authors use the rule that the ranges of the variables to be covered should be transformed into the same unit of length. This makes the model fit into an n-dimensional unit cube. The precise effect of scaling factors on the path followed is a matter of technical interest and is considered briefly in the appendix.

There is one very interesting feature of valleys that throws light on the structure of the criterion function. In some cases, when the valleys have a sharp bottom edge, it may be found that along one branch of the contour a particular design limit is reached and on the other a different limit satisfied. This situation was met in studies of a nuclear station and the evaluation rearranged so that both limits were automatically satisfied. In this way the time to reach the solution was substantially reduced.



A system of design variables can be represented by contour surfaces with valleys and peaks representing favourable combinations. The optimization path is shown from P_0 to G.

MOVING IN THE RIGHT DIRECTION

A rapid solution is always the practical aim. The more careful are the surveys in the neighbourhood of a point, the more accurate are the estimates of the appropriate directions. On the other hand, the majority of realistic criteria involve complicated non-linear functions of the variables and the "correct direction" in which to proceed changes markedly over the surface. In general, it is desirable to survey approximately and move quickly. The authors have found that simple linear surveys give quickest results.

As the optimum point is approached, some of the first derivatives will become very small and there is a danger that the results of a linear survey may be swamped by rounding off errors. When this happens the process becomes erratic and should be stopped. However, in most engineering and commercial applications the solution can be located to within the required limits of accuracy (say $\frac{1}{2}$ per cent) before this numerical difficulty is encountered. Where greater accuracy is required a procedure based on second derivatives should be used. One very elegant process, developed by a former colleague, N. J. Hodson, depends on fitting a hyperquadric to the surface locally and exploring in the direction of the centre.

The path followed from the initial point to the optimum approximates to that of steepest descent and only a small region around it is explored in the optimization. Its length may be expected to increase approximately as $n^{1/2}$, where n is the number of variables, as this is the length of the diagonal of an n-dimensional unit cube. Furthermore, each time a linear survey is made in the neighbourhood of a point, $(n + 1)$ evaluations are required—the base point and one in the direction of each factor. Thus it is reasonable to expect that the number of evaluations necessary to reach the optimum should increase as $n^{1/2}(n + 1)$. The striking feature is that although this function increases indefinitely with n, its growth is very much less rapid than that of the exponential a^n which indicates the number of evaluations needed for the conventional factorial approach.

Naturally, the actual time taken to reach a solution depends on the starting point, the nature of the function and the time required for each evaluation. However, on the basis of the above qualitative analysis a tentative appraisal of the cost of finding a solution may be given by assuming that the required number of evaluations is proportional to $(n^{3/2} + n^{1/2})$.

APPENDIX

The direction of steepest descent or ascent of a function may be expressed in terms of the first partial derivatives. Consider a function of two variables $Z = f(X,Y)$. The difference dZ in the values of the function at two neighbouring points P(X,Y) and P′(X + dX, Y + dY) is

$$dZ = \frac{\partial f}{\partial X}dX + \frac{\partial f}{\partial Y}dY \quad . \quad . \quad (1)$$

Also the distance ds between P and P′ is

$$ds = \sqrt{dX^2 + dY^2} \quad . \quad . \quad (2)$$

Now if this distance is kept constant and dX and dY are changed until dZ is a maximum, PP′ will be in the direction of steepest ascent. Thus, by ordinary calculus[3]

$$0 = d(dZ) = \frac{\partial f}{\partial X}d(dX) + \frac{\partial f}{\partial Y}d(dY) \quad (3)$$

and

$$0 = dX\,d(dX) + dY\,d(dY) \quad . \quad . \quad (4)$$

Hence

$$dX : dY = \frac{\partial f}{\partial X} : \frac{\partial f}{\partial Y} \quad . \quad . \quad (5)$$

The formal extension to more variables is simple.

The effect of scaling factors may be studied as follows. In a model with n variables, X_i, the direction of steepest descent, is given by

$$\delta X_i = -\lambda\frac{\partial Z}{\partial X_i} \quad i = 1, 2 \ldots n \quad . \quad (6)$$

where λ is a constant.

The X_i are related to the original design variables x_i by scale relations of the form

$$X_i = \mu_i x_i$$

Hence the changes in the x_i corresponding to the changes δX_i are given by

$$\delta x_i = \frac{\delta X_i}{\mu_i} = -\frac{\lambda}{\mu_i}\frac{\partial Z}{\mu_i \partial x_i} = -\frac{\lambda}{\mu_i^2}\frac{\partial Z}{\partial x_i} \quad . \quad . \quad (7)$$

Thus the changes predicted for the original design variables are dependent on the scales chosen. If the contours in the model are elongated in the direction of a particular variable, then equation (7) shows that the "step" in that direction may be increased by decreasing the corresponding scale factor μ_i. In this way the path in the neighbourhood of a narrow valley may be directed more towards the optimum.

REFERENCES

[1] Ramsay, A. S., *Advanced Dynamics*, Part II, Cambridge University Press, 1947, Section 9·9.

[2] Saaty, T. L., "Résumé of Useful Formulas in Queueing Theory," *Journal Op. Res. Soc. of America*, Vol. 5, April 1957.

[3] Lamb, Sir George, *An Elementary Course of Infinitesimal Calculus*, Cambridge University Press, 1947, Section 197.

A second article will illustrate the technique by examples.

Models Make for Economy in Materials

Modern structural designs, achieving a lightness by the minimum use of materials, are rarely amenable to "paper" analysis. Only by building a model and simulating the loading conditions is it possible to determine the load distribution and the deflections that will occur in the prototype.

STRUCTURAL analysis by models is not so far advanced or so well accepted as ship and aerodynamic tests using models, nor, within the field of civil engineering, is it so well established as hydraulic models for investigating river and harbour works. Historically speaking, the direct measurement structural model as a design tool is probably as old as those used in other branches of engineering but, with the exception of those used to investigate the stresses in concrete dams, it is only of recent years that it has received the attention that it deserves.

So quickly has its status been advanced during these last five years or so, that it is probably true to say that no important authority would now refuse to accept a structural design dependent upon a model analysis for justification. Most leading consulting engineers have made use of the technique and many of the county councils and British Railways, to name but two important groups, have accepted designs that are materially dependent on the evidence obtained from model tests.

MODEL FACILITIES

A number of structures that were designed with the aid of a model have now been completed and checks made of the deflections that occur under actual loading and these compared with the expected figures obtained from the model test. The agreement has been sufficiently close to warrant great confidence in model techniques. With repetition of a structural form, say for hyperbolic paraboloid roofs or a particular type of cellular box bridge deck, and with the experience that comes with successful completion of a new structure, the need for an elaborate model test may well recede. But for every new structural form that is evolved, it is likely that "paper" analysis will be insufficient, if not impracticable even with the help of either a digital or analogue computer, and it will be necessary to rely on a direct measurement model for completion of the design.

Generally speaking, the equipment required for making and testing a direct measurement structural model is more than a design office can find the space for, though there may be the personnel capable of carrying out the tests. The design and execution of a structural model calls for similar qualities of engineering intuition and judgment as for the structure itself, but the model designer is even more dependent on these qualities since his design is not circumscribed by pre-determined requirements such as over-all size and appearance.* On the other hand he does not have quite the same degree of responsibility, for his model can fail without too many repercussions, though his ultimate contribution to the final design may be equal to that of the designer of the structure. All of the departments of civil engineering at the universities have the necessary equipment and apparatus, as well as space to build and test models, and many of them now have experience in this work. In addition, the Cement and Concrete Association offers a model testing service at its Wexham Springs research headquarters. So far testing has been carried out in the main structural laboratory but a new models testing laboratory is nearing completion. It is humidity and temperature controlled, and the floor contains a grid of load anchor points, each capable of maintaining a point load of 7½ tons.

In addition to the the direct measurement models with which this article is primarily concerned, there are at least two other techniques that have a wide application. The first, reciprocal displacement models, require little apparatus and are conveniently employed in a drawing office, but the second, photoelasticity, does need very special equipment and considerable experience for its successful use.

Reciprocal displacement models make use of Clerk Maxwell's reciprocal theorem and are used for determining redundant reactions. Though particularly suited to plane frame analysis, there is no inherent limitation that stops them from being used for three-dimensional structures. The model is usually cut from celluloid or perspex, the centre line of the model being scaled directly from the prototype, while the width of the model at any section is made proportional to either the area or the second moment of area at the corresponding section, according to the critical action being investigated. Relatively large elastic distortions are applied to the model and the ratio of the deflections in any given directions are proportional to the loads or reactions at the corresponding points and in the same directions. The movements are of such an order that they can be effectively measured with a good steel rule that has close graduations.

Photoelastic techniques, using polarized light which is passed through a transparent model loaded in the same way as the prototype, are now well known. They are particularly valuable for investigating points of stress concentration, but they are equally useful for determining the magnitude of carry-over effects in complex structures. By making use of the so-called frozen stress techniques, where the model is heated and then cooled under load so that the stress fringes are "frozen" and slices of the model can be examined in turn, photoelasticity can be exploited for complex three-dimensional problems. To be set against the complexity of the technique, is the powerful advantage that it will almost certainly show up the point of highest stress, whereas all other techniques require some prior analysis to indicate where the high stresses may occur and even then the precise location and direction may have to be tracked down. So far as concrete structures are concerned, photoelasticity and the use of perspex models generally may have disadvantages due to the difference in the value of Poisson's ratio for concrete and Perspex.

APPLICATIONS

The direct measurement model has proved most useful, considered by the number of applications there have been, to the new roof forms, such as hyperbolic paraboloids and shell roofs generally, and for large bridge structures. This type of model has also been used effectively for investigating certain conditions in multi-storey buildings, particularly to find the position of the shear centre of the tower and the torsional stiffness of a structure in which the cladding makes a significant contribution to that of the main frame.

"Models" are also being used at full scale to investigate the conditions existing in such components as concrete bridge hinges, but the forces involved are so large, and the framing required so heavy, that parallel tests are in progress on smaller models to examine scale effects so that future work may be restricted to the more convenient small-scale model.

Of the British bridge structures that have been investigated by models, perhaps the best known are the Clifton bridge at Nottingham (completed and opened to traffic in 1958), the Hammersmith Flyover in London (for which the last principal members have just been erected and due to be brought into use later this year) and the Medway bridge (the model is illustrated in Fig. 1 and work at the site was begun only last year). All three of these models were tested at Wexham Springs by the Cement and Concrete Association on behalf of the consulting engineers concerned.

Of these three, the Clifton bridge model (made for Travers Morgan and Partners) differs from the other two in that it was made of Perspex whereas the other two have been made in a "micro-concrete," the aggregate being scaled down much as the model was.

The Clifton bridge is a skew structure over the River Trent and consists of balanced cantilevers with a suspended span to give a main span of

* S. R. Sparkes and J. C. Chapman, "Model Methods, with Particular Reference to Three Recent Applications", *The Structural Engineer*, vol. 39, No. 3, March, 1961.

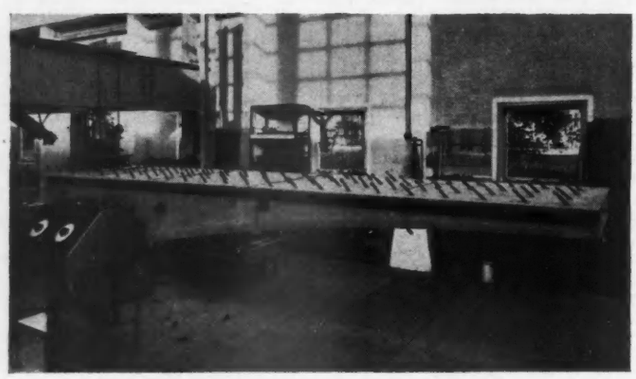


Fig. 1 (left) The model (scale 3/40) of the Medway Bridge which was tested at the Cement and Concrete Association's laboratory at Wexham Springs.

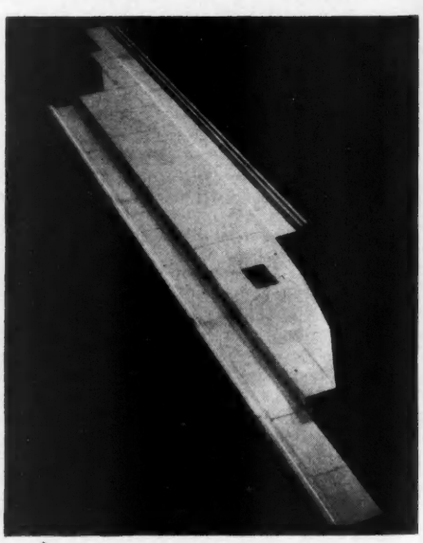


Fig. 2 (right) A model made in Araldite epoxy resin of a prestressed concrete railway bridge; the platform is an integral part of the bridge structure. The tracks are on cantilevers on both sides of the platform "box." (Model scale, 1/48.)

Fig. 3 Model at 1/10 scale of a hyperbolic paraboloid shell roof.

275 ft (cantilevers of 87 ft 6 in and a suspended span of 100 ft) and tail spans of 125 ft. The model was very small, 1/50, and was used to find the load distribution, the reactions and the effect of the prestress on the skew cantilevers. No prestress was applied to the model during the initial tests to find the load distribution properties and the reactions. With these tests complete, the prestress was simulated separately and the effects measured independently.

The model for the Medway bridge was much larger. For one thing, the bridge itself is very much bigger—the main span is 500 ft long, consisting of two 200 ft cantilevers and a 100 ft suspended span, and the tail spans are each 300 ft long—and the scale was 3/40, chosen for convenience of casting the slender web sections which are only 9 in thick on the actual bridge. The same order was followed in building the model as the consulting engineers, Freeman Fox and Partners, envisaged might be used at site. The bottom slab, complete with ducts for shear cables, was cast on a soffit shutter, and then the internal and external webs, which varied between 29½ in and 6 in in height, were cast up to the level of the underside of the top slab; the pier and end diaphragms were next cast, though the pier member was initially kept low so that the shuttering for the top deck could be withdrawn. After completion of casting, the 45° shear cables were loaded and, after applying a vertical load to the pier diaphragm, the longitudinal prestress applied.

VIBRATION FREQUENCIES

Tests were carried out on the model with concentrated point loads and with scaled versions of the Ministry of Transport's abnormal loading to determine the distribution characteristics. Dead load effects have also been examined and stress distribution in the webs measured for severe load conditions. Tests were also made to determine the period of vibration of the model and hence the fundamental frequency of vibration of the actual structure. The model was subsequently used for a research programme to investigate the general behaviour of this bridge type with a view to developing the accepted design procedure.

The form of the structure for the Hammersmith flyover has already been described and illustrated in detail in ENGINEERING (17 Feb. '61, p. 246). It is a multi-span structure comprising a continuous hollow spine beam carried on a single line of columns. The whole of the superstructure is precast (except for thin *in situ* filling between sections) and prestressed longitudinally; the two carriageways are supported on cantilevers that project from the diaphragms of the main spine beam and comprise precast planks with an *in situ* topping. The principal spans are 140 ft long and the overall width of the deck is 61 ft. The loading specified is for either or both of the carriageways fully loaded so that conditions of combined bending, shear and torsion exist at the piers. The consulting engineers, G. Maunsell and Partners, wished to determine the mode of failure under the combined stress conditions and a model seemed the best way of doing this.

The scale of the model is 1/12. The microconcrete used was 1 : 3 : 6 mix with a maximum aggregate size of ⅜ in and a water ratio of 0·47, and all units were vibrated on a vibrating table. To assist the investigation a number of electrical resistance strain gauges were attached to one of the spine beam units prior to erecting the model.

A different approach to the bridge problem is illustrated in Fig. 2. This photograph shows a scale model (¼ in to 1 ft) of the recently constructed bridge at London Road Station, Manchester. The model is 6 ft long and was cast in Araldite epoxy resin by McKinlay Electrical Manufacturing Company Limited for the London Midland Region of British Railways. The design is most ambitious for the bridge has a high degree of skew and carries a platform with a rail track on both sides. The designers decided to make use of the platform as a box structure supplying most of the longitudinal strength of the bridge and to put the tracks on cantilevers protruding from the side of the platform box; conditions were further complicated by the box being punctured by a luggage lift. The bridge, which is contained within a most confined site, has been completed in prestressed concrete and the model was required to investigate deflections under various conditions of loading which, under most circumstances, produced severe torsion.

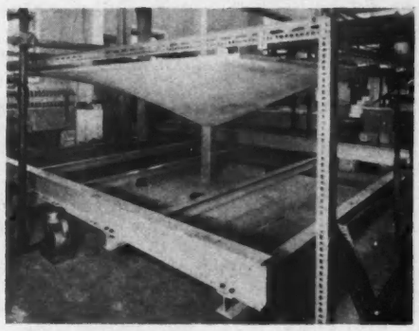
RELEASING FORMWORK

The main work at Wexham Springs on bridge construction has been concerned with fundamental studies of deck systems and of components such as anchorages for prestressing cables. Similarly, for shell roofs, most of the work has been fundamental studies, involving models such as that shown in Fig. 3. This particular model was originally made and tested to investigate a structure designed by Dr. K. Hajnal-Konyi for a garage and showroom. The roof of the structure comprises four shells together making a square roof; each shell is 47 ft 6 in square in plan and there are glazing strips between each pair. The common low points of the shells were supported on columns and frames, and joined by prestressed tie-beams cast monolithically with the shells; the high points were carried on tubular steel columns. The rise along each edge of a shell was 14 ft 6 in and on the basis of a theoretical analysis the shell thickness had been made 2½ in increasing to 9 in adjacent to the edge beams, which were 18 in deep by 12 in wide. The major problems still to be solved were (*a*) the effect of the tie beam on the stresses in the shell and (*b*) the distribution of stress and deflection of the shell under load. The model was built in reinforced mortar to a scale of 1/10 and the loading technique that was used then is shown in the illustration. After satisfying the designer's requirements the model was used for a long series of tests and finally loaded to destruction.

Another double curvature roof examined at Wexham Springs was that for the Texas Instrument Company's factory at Bedford (ENGNG., 17 June '60, p. 820) and illustrated in Fig. 4. This roof was designed by Oscar Faber and Partners and at their request a reinforced mortar model (scale 1/6) was tested under uniform and eccentric loading.

TWO NEW SHELLS

Currently the Cement and Concrete Association are testing a 1/12 scale model of the largest roof shell so far designed, at least in the United Kingdom, that for Smithfield market in London. It is an elliptic paraboloid 225 ft long by 135 ft wide and the rises at the midpoints of the sides are 20 ft and 10 ft respectively; the membrane is to be 3 in thick. The analytical problem is complicated by the fact that the shell is supported by a large number of columns around the periphery and, in addition, that the spacing of the columns is not regular. The purpose of the model is to determine the degree of prestress required, the deflections and stresses in the membrane, the loads that will occur in the columns, and to check that when the



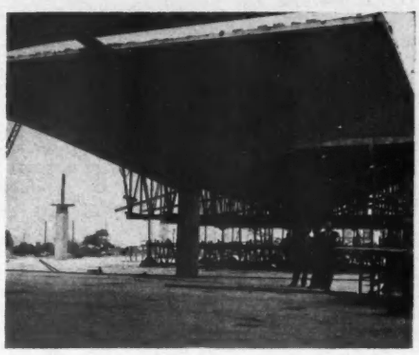


Fig. 4 Above, the model (scale 1/6) and, below, one of the finished umbrella roof shells for the Texas Instrument Company's factory at Bedford

prestress is applied the shell will lift to free the shuttering. In order that the prestress in the model can be easily varied the tendons have been placed on the outside of the model's edge beams. Uniform loading of the shell has been obtained by attaching to the top of the shell an airbag which can be pressurized, so applying a uniform load. The consulting engineers for this shell are Ove Arup and Partners of London.

An interesting roof model which is soon to be built at Birmingham University will be used to investigate a shell that is to cover a swimming pool for the university. Designed by Flint and Neill of London, the plan area of the shell is about 150 ft long by 90 ft wide. Part of the shell consists of two membranes separated by "egg box" stiffening webs, the membranes being punctured for the inclusion of roof lights. Longitudinal sections are sine functions to give reverse curves and the transverse sections a series of parabolas which are splayed along the outer edges.

The model, which is to be built to check deflections and strains in the membranes, will be 1/12 scale and of reinforced mortar. To date only the male mould for casting the lower membrane has been made, by Partridge's Models Limited of Paddington, London. This was made by cutting a number of formers to shape, fitting them together as an egg box, covering them with laths and smoothing the surface. With the lower membrane cast, the plaster stiffening webs will be put in place. To make the upper membrane it is proposed to fill the spaces within the webs with an expanded plastic such as Polyzote and to cover the whole with a female mould. After the plaster has set, the plastic will be dissolved in a hydrocarbon solvent; the solution will be of very small volume which would have little effect on the model and, anyway, the application of a little warmth will quickly evaporate it.

It has been intentional that this article should put an emphasis on the use of structural models for the design of roofs and bridges particularly, this being a more recent development than the better known tests on models of dams and the more established use of hydraulic and aerodynamic models to help the civil engineer.

Reactor Simulators

ANALOGUE computers are playing an increasing role in the training of nuclear engineers and reactor operators and in the study of reactor physics. A console that closely resembles that of a reactor enables the student to familiarize himself with the reactor controls and obtain a thorough understanding of the function of the many parameters involved in nuclear physics. Through his mistakes he is able to learn the consequences, since the system of warning and alarm controls are identical with those on an actual reactor.

Digital and Analogue Computers

Most digital computers are operated by a process of addition, for example multiplication by repetitive additions, and trigonometric functions by means of a convergant series. With the digital computer, the results are usually punched out on tape or typed, and it is possible to incorporate a digital-to-analogue conversion so that the output is in the form of a graph; but since operating time must be carefully considered, due to the high expense, this is not an ideal solution.

The analogue method differs from the digital chiefly in that the method of solution is continuous compared with a finite solution. The accuracy is inferior to that of the digital, but where an overall picture is required instead of a specific answer, the analogue has obvious advantages. It is also much the cheaper machine of the two.

Differential Analyser

The reactor simulator is principally a differential analyser for the solution of the reactivity and delayed neutron equations. It consists of high gain amplifiers which may be connected adders, differentiators or integrators. In the amplifiers the feedback is supplied through capacitors or resistances from the output to the input. The electrical network represents the mathematical problem and the computing components are interconnected so that voltages at certain points in the system satisfy the equations to be solved for specific initial conditions. ("A General Purpose Electronic Analogue Computer," by R. J. A. Paul.) A block diagram of the Vickers Mark IIa simulator is illustrated.

Possible Experiments

The number of experiments that may be performed on a reactor simulator are limited, but the comparative cheapness of a simulator compared with a reactor is a strong point in favour of the former. Some of the possible experiments are as follows. The normal approach to criticality and steady state power operation can be made by manipulation of the control rod movement and observation of the doubling time meter. Critical settings may be made by the measurement of doubling time. The effects of step changes in reactivity can be made and the variation with different mean prompt lives can be examined. In a supercritical reactor, the steady doubling time is a function of the excess reactivity and the proportions of the delayed neutrons; thus, for a given reactor, it is possible to deduce an empirical formula for the doubling time. By using the automatic control to maintain the reactor at a constant power, and noting the variation in the position of the control rods with a change in the reactivity, the control rods may be calibrated. Investigations can be made of the shut-down power level and the effect that the source and the loss of neutrons by leakage has on this value. On shut-down a study can be made of the xenon poisoning which is produced by the radioactive decay of tellurium 135.

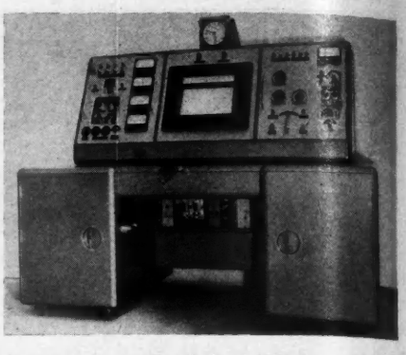
Controls

The number of controls fitted to any machine is dependent on the size, but most machines are able to take into account the following effects simultaneously: neutron kinetics, photo-neutrons, neutron source, linear and logarithmic power indication, reactor period, control rods, heat transfer, poisoning, applied external reactivities and external loops for power station simulation. The voltage range of a computer is limited to about 100V, but as the range of reactor power extends to more than ten decades and reactor power is proportional to voltage, the small computer voltage range has generally been a severe limitation. Recently, however, the introduction of a logarithmic form for simulators has successfully extended the number of decades sufficiently to cover the reactor power range.

Temperature Effects

In zero power reactors the effect of temperature is very small, but temperature variation plays an important part in high power reactors. Accurate simulation of heat transfer at full operating level is thus more difficult and the need for a computer vital, because it becomes necessary to programme all the heat transfer equations individually.

The accuracy obtained for the calculation is dependent on the number of amplifiers that the machine has available. If fast transients are to be considered, about 100 amplifiers will be needed in the case of the coolant boiling to give the required accuracy. It is the number of amplifiers which add heavily to the final cost of the equipment. However, in a simpler case, heat transfer can be represented by two differential equations of the first order where constant coefficients are assumed, with the mean uranium and moderator temperatures taken as the independent variables.

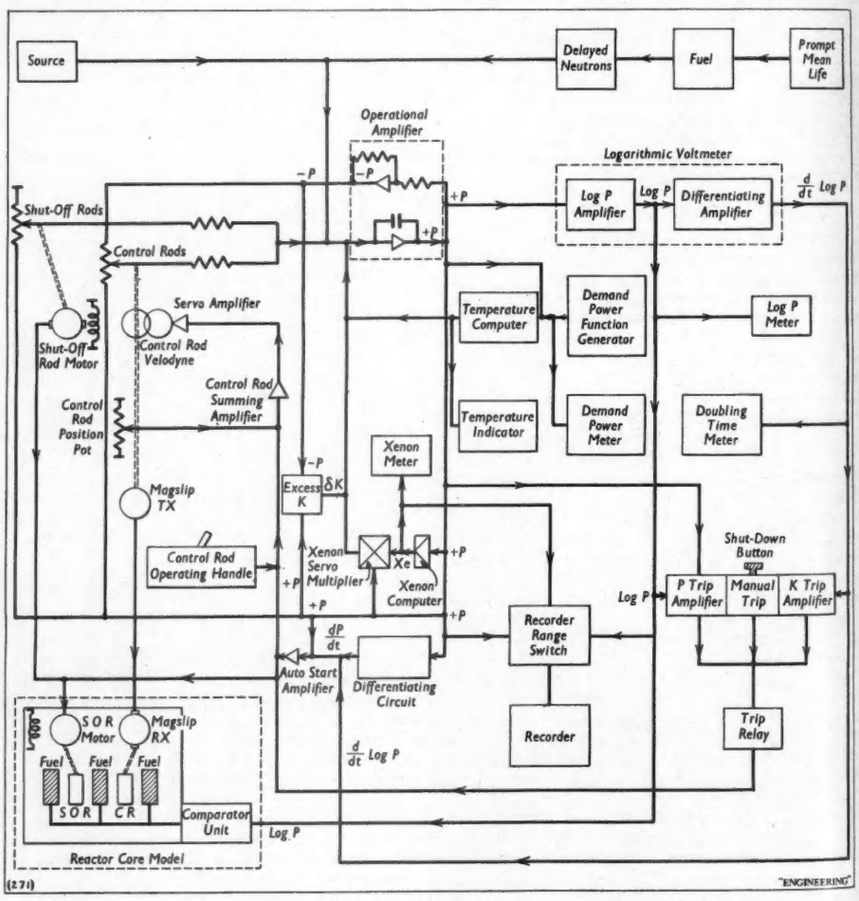


The control console of the Mark IIa simulator. The fuel enrichment, fuel type controls and operating meters are on the left; the recording chart in the centre; and the control rod operating lever and instrumentation on the right.

Models Available

There are numerous makes of reactor simulators available and the majority of manufactures in the analogue computer field are investigating the possibilities of adapting their instruments for nuclear work. For example, Short Brothers and Harland have recently provided a modified Simlac for the Calder Hall Operations School. It contains over 200 amplifiers which are transistorized, and therefore dissipate little heat.

Another simulator to be installed shortly is the Elliott type ND 481 at the Berkeley Nuclear Laboratories. However, if these models prove too costly for individual customers the IBM Data Centre, which was opened earlier this month, hires out its equipment for approximately £250 per hour. In the smaller range of simulators, manufacturers include Vickers Armstrongs (South Marston) Limited, Miles Highvolt Limited and General Precision Systems Limited.



Block diagram of the Vickers Mark IIa reactor simulator.

Companies

Heavy Engineering and Ice Cream

THE names of all those companies for whom JOHN LAING AND SON have recently completed or are undertaking major works read like a Debrett of British Industry.

Vickers - Armstrongs (Engineers), Head Wrightson, Petrochemicals, Richard Thomas and Baldwins, Colvilles, Mobil Oil, the British Transport Commission, Bowater Packaging the list of those whom the busy and expanding Laing organization serve is naturally also a roll call of some of the interests most active in modernization and expansion.

Mr. W. Kirby Laing, the company's chairman, points out in his annual review how two main factors made 1960 a difficult year. The exceptionally wet weather of the summer and autumn caused considerable dislocation; despite the large volume of construction work going on competition was particularly fierce.

At Gloucester, for T. Walls and Sons (Ice Cream) Limited, the company is building what is believed to be the largest ice cream factory in the world, at a cost of £1¼ million, including a two-storey production block, two-storey office building, wafer factory, cold store canteen and boiler house. For Bowater's paper products division, Laing are building what will be the largest single storey factory in Kent. When completed it will house the production of most of Bowater's flexible packaging products.

Among the university, technical college and school buildings on which the company is working is the new Commonwealth Institute which has the first large hyperbolic-paraboloidal roof to be put up in the United Kingdom. Laing have also been much involved with new physics buildings: the new physics building for the Imperial College of Science and Technology, which was opened last October, and two others at Newcastle and at Durham.

African Development

Suitable building land has been harder than ever to find but the year was still one of expansion for LAING HOUSING. Estates were developed or begun in Yorkshire, Sussex, Hertfordshire, Berkshire, Middlesex, Somerset, Bedfordshire, Surrey and Worcestershire. A number of new estates are to be started this year.

Overseas Laing have a variety of schemes on hand in many parts of Africa. In South-West Africa the 40 mile Otavi-Tsumbeb road was completed 30 weeks ahead of schedule. In Nyasaland the company is helping in the development of the Northern province.

The chairman points out that the well known racial problems of South and Central Africa, and their equally well appreciated effects on the general economic conditions, have been anticipated by the company which has streamlined its organization and, particularly in the case of South Africa, moved staff to important and extensive work elsewhere.

The Laing report makes no attempt to predict the effect of South Africa's withdrawal from the Commonwealth, but feels sure that prolonged political uncertainty in Northern and Southern Rhodesia will depress investment and lead to falling trade, a state of affairs not to be swiftly reversed.

Schedules and deadlines can have a quite different significance in Canada. On the Lanark Avalanche Shed contract, protecting a section of the Trans-Canada Highway as it passes through the Rocky Mountains, no completion date was set by the Columbia Department of Highways but the deadline was effectively imposed by the local weather conditions. If the workmen were not to be exposed to the danger of the first avalanche of the season, the job had to be finished by 10 November. Working time was three and a half months and work was completed just a day or two ahead of the first avalanche movement.

Export Guarantees Anticipate United Europe

One of the most interesting of the organizations spanning the European Free Trade Area and the European Economic Community and which also has United States membership is the Amstel Club, an association of finance institutions who have entered into reciprocal agreements for financing imports and exports between their countries.

Membership of the club gives the participating institutions a valuable position in the arranging of export credits for industrial machinery, farm equipment, vehicles, plant, and domestic equipment and goods.

The Amstel Club members, who met in Zurich last month, specialize in two types of credit; medium term finance for the retail purchase of goods in markets overseas, and in appropriate cases the provision of finance to enable an overseas distributor to import goods and hold them pending sale. Medium term credits are usually available for two or three years, up to five years can be fixed in some cases. Import and stock finance is normally for between three and six months.

Britain's Amstel Club member is the UNITED DOMINIONS TRUST, who have issued an informative booklet on the association, The Amstel Club. Under the heading, *How the Amstel Club works*, the booklet sets out the customary procedure.

The manufacturer first gives the name and address of his customer, the importer, to the Amstel Club member (UDT in the UK) with details of the credit required. The importer may be a distributor or concessionaire or buyer of the equipment for his own use.

At the same time the manufacturer informs the importer that at his request the Amstel member will attempt to arrange the facilities wanted and he will ask the importer to meet the appropriate bank in his own country.

The Amstel member gives the name of the importer and details of the facilities required to their correspondent bankers in the importing country.

The correspondent bankers meet the importer and negotiate. If the importer is a distributor they arrange to offer medium term credit to his retail buyers and discuss short term finance requirements with the distributor. For a buyer, a medium term credit is arranged immediately.

The correspondent bankers then inform the finance institution of the credit they are prepared to give and the terms they have agreed with the importer. Where import or stock finance is arranged this normally takes the form of a revolving credit against which continuous shipments can be made.

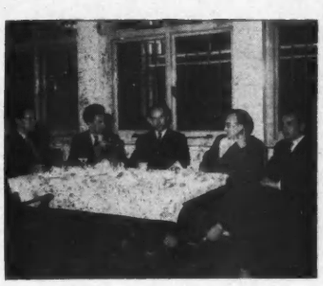
The Amstel member then informs the manufacturer that the credit has been arranged and he can get on to shipping the goods.

The finance institution collect payment of the manufacturer's account from their correspondent banker and pay the manufacturer. Every effort is made to arrange payment in accord with the manufacturer's normal terms of contract. The credit risk is the correspondent banker's responsibility and there is no liability on the manufacturer.

Through the Amstel Club it is possible for the United Kingdom manufacturer to offer credit to customers in the Common Market countries, in EFTA, and in Commonwealth countries where the United Dominions Trust is represented and in the United States.

Russian Exchange Students Study Oxygen Detection

Exchange students from the Soviet Union who visited the GEORGE KENT factory at Luton were particularly interested in the company's equipment



for the detection of oxygen in gases and in pneumatic control equipment.

The Russians are in Britain on an extended visit to work at British universities and to study mining equipment and techniques. An interest in Kent flow measurement and control equipment, observed working in a number of United Kingdom factories, took the students to the Luton factory for closer examination.

Over tea, Mr. R. S. Medlock, engineering director, and Mr. J. E. Lee, export sales executive, discussed electronic measurement and control with their visitors (*inset*).

Agency Agreement on Lapping Machines

ALFRED HERBERT, of Coventry, and FLEXIBOX, of Manchester, have concluded an agreement by which the Coventry company are appointed sole United Kingdom agents for the sale of the Flexibox range of lapping machines. The agreement takes effect from this month.

Flexibox lapping machines are used for the production of optically plane surfaces on parts made from almost any constructional material including ferrous and non-ferrous metals, plastics, glass, carbon and semi-conductor materials.

The variety of applications is swiftly increasing as the potential of the machine lapping process for the production of high degrees of surface finish and flatness on engineering components becomes more widely known.

From Loss to Profit on Record Turnover

Recovering slowly but steadily from the effects of the cables price war, JOHNSON AND PHILLIPS, on a record turnover of about £10 million returned a profit last year of £24,171, a move back to the credit side of the line after 1959's loss of £91,084.

Mr. William Glass, the chairman and managing director, observes that while this cannot be regarded as satisfactory it does indicate a turn for the better. He predicts that at " this time next year " there will be much more to show for the efforts of the company.

Plant departments were working profitably but the losses made by the cable sections, which were working at a substantially increased level of activity, more than cancelled out this income.

The company's results have been inevitably affected by the numerous period contracts for cables concluded at the low prices of 1959. These have now been completed. All those of substance have been renewed at selling prices bearing rather more realistic relations to the costs.

That the cable industry, enjoying a record level of demand for its products, should be obtaining such poor returns is rightly described by Mr. Glass as ridiculous. In the long run any industry can only stay competitive in world markets, and at home, if it is making the sort of earnings that allow it to carry out the necessary research and development. That money is not currently being made in the cable industry.

In addition to cables, Johnson & Phillips manufacture switchgear, transformers, capacitors, submarine cable laying gear and overhead line materials. These form an important and growing part of the company's performance but the cable element is still the key to the prosperity of J. & P. If the level of cable demand were to fall back, this side of the business could very easily slide back into losing money.

Overseas the subsidiaries and branches have earned useful profits. In India, Pakistan and South Africa the J. & P. interests have had a good year; in Australia results were disappointing. The already announced investment to be made by Johnson and Phillips in India is taking the form of supplying a substantial part of the cable making machinery for a factory now being put up near Ahmedabad. The company has exclusive rights for the output of the factory. Production from the BRITISH INDIA ELECTRIC CONSTRUCTION COMPANY'S switchgear works, with which J & P have a very close association, is being enlarged to meet the demand.

The J & P switchgear factory in Pakistan is being extended and has been converted into a local public company with 40 per cent participation from within the country.

Looking ahead, Mr. Glass reports that orders, especially for the home market, have been well kept up throughout 1960 and have further increased in most departments in the first five months of 1961. It seems likely that the year will end with a level of profit more in accord with the high volume of sales than it has been recently.

Making Cast Metal Moulds With Undercuts

Here are details of a process for making split moulds for articles which pose pattern-making problems. It relies on a flexible vinyl mould.

A PATTERNMAKER of long standing in the industry has developed in the last year a process for casting split metal moulds with undercuts on their surfaces. He is Mr. A. E. Young, who now works in his own business from 112 Evelyn Crescent, Sunbury on Thames. His process leads to the making of inexpensive pairs of moulds, and the potential accuracy on dimensions, coupled with the good surface finish which he claims to get, might lead to this becoming an established method of its own.

It depends for its success on the use of flexible moulding material. This could well be one of the cold-curing rubbers now available, but Mr. Young has chosen to base his method on hot-pouring vinyl compounds such as are obtainable from Vinatex Limited under the name of Vinamold. Vinatex say these can be remelted and used up to about 25 times, which makes them inexpensive to use.

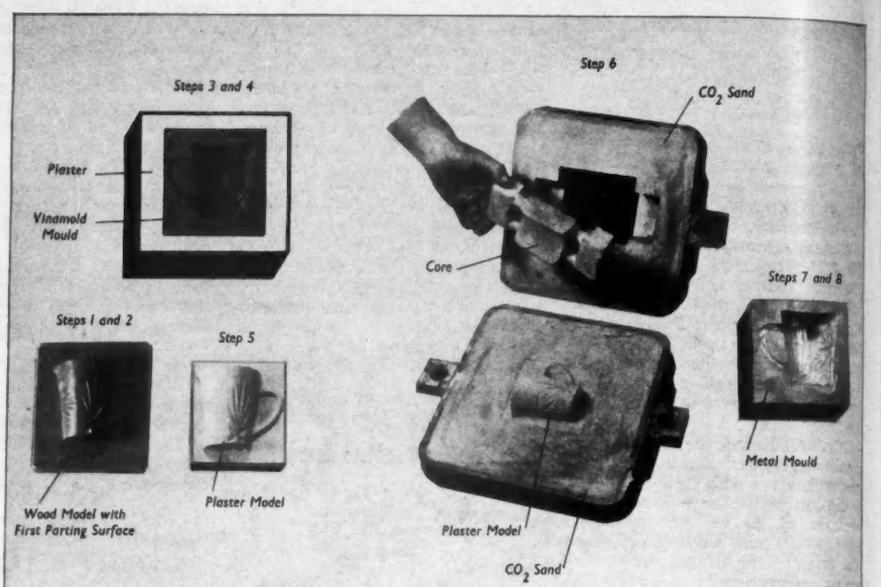
There are several grades of Vinamold which range in hardness and elongation. With the softest and most flexible one, Mr. Young says he can tackle undercuts of a least $\frac{1}{2}$ in on the end faces of a cylinder about 4 in long; but this does of course depend rather on the severity of the undercut and the relative shapes.

Split moulds such as can be made by this method are needed by firms who blow mould plastic bottles and who make injection mouldings generally. During the year in which he has been working on this process, Mr. Young has aimed to produce his final moulds in Tandium metal (a proprietory alloy). In other words, his end-product is at the moment limited to production of moulds for handling low temperature softening materials such as plastics. It is possible to imagine an extension of the basic idea so that moulds with undercuts could be made in higher temperature alloys.

This vinyl copying process is not facilitating the casting of articles not possible before. But it does seem (from figures based on his 20 years' experience in the trade, shown here) that the new process is much less expensive than the two alternative processes, namely machine-copying, or casting from a pattern with separate attachments (or " prints ") to take care of the undercuts.

The main savings in the new process appear to be realized when a negative mould is required—in other words one used for making a final positive article in. It can then be an expensive business making wooden patterns (either for machine copying in metal or for use as a straight pattern in sand casting) with inside detail and undercuts. It is easier, says Mr. Young, to make a positive model of the article for which the metal moulds will be used and then to go through his vinyl copying process to finish up with the negative mould.

The steps in the process are outlined in the diagram above. The illustrations which appear here are taken from actual steps in making one half of a metal mould. Note that the starting point is a model of the article itself made with dimensional allowances for contraction of the metal during casting and for spring-back in the final plastic moulding process. The metal casting step was performed by Wandsworth Foundry.



STEPS IN PROCESS:—

1. *Make Wood Model*
2. *Fix First Parting Surface Construction Near Centre Line of Wood Model*
3. *Cast Vinamold Mould Around Wood Model*
4. *When Set, Pour Plaster Around it for Support*
5. *Make Plaster Model from Vinamold Mould*
6. *When Set, Use Plaster Model in Base of Moulding Box. Core in Top Part of Moulding Box Creates Cooling Passages*
7. *Cast Metal*
8. *Clean and Finish Metal Mould*
9. *Repeat Whole Process for Other Half of Mould. Obtain Reverse Parting Surface on Wood Model by Casting Plaster on Model and Removing First Parting Surface.*

The development of this process was undertaken concurrently with fulfilling orders for moulds both with and without undercuts. For some of these it was far easier to use normal methods of patternmaking, says Mr. Young; certainly he is not attempting to promote his method for all mould making. His main customer has been Middlesex Toy Industries who were once associated with the division of the Reed Packaging Group making polyethylene bottles and drums. There are now several plastic moulders, Mr. Young says, who are showing interest in having moulds made by his process.

For simple shapes without undercuts, the new method is not needed. A pattern can be made quite simply which is used directly in making a sand mould for casting metal into. However, where undercuts are present, it becomes necessary in this established process either to use a pattern with prints so that sand cores can be fitted in the moulding box; or else the pattern must have detachable pieces fixed to it with dovetail joints so that the part near the undercut can be removed without breaking the compressed sand. With sand casting, moreover, Mr. Young says he always obtains a slightly rough surface, which for moulds for the plastics industry means a great deal of hand finishing. His process can substantially reduce the amount of finishing, he claims (and realises in practice). The mould material is plaster which yields a much superior cast metal surface when metal and pouring temperatures are correctly chosen.

The success of this process depends largely on obtaining a flexible half mould in Vinamold which permits pouring of plaster into it so as to obtain good dimensional accuracy, yet which has sufficient flexibility to allow the set plaster to be removed. You will notice from the steps described above that the Vinamold copy is backed up with plaster itself, and this is one step taken to obtain dimensional accuracy. Another step is to use two grades of Vinamold simultaneously in the pouring process so that the better dimensional stability of the harder grade is obtained at all places other than where the greatest flexibility is needed.

Development has now reached a point where Mr. Young can make moulds up to about 12 in maximum dimension with a largest total error of $\frac{1}{32}$ in. He is aiming within the next 12 months to improve techniques to a point where the accuracy will be 0·005 to 0·010 in on such small dimensions. When this is achieved, it should be possible to make moulds competitively for straight short-run plastic injection mouldings where such tolerances are demanded.

Other than the present limitation on size (and this could be increased with experience, says Mr. Young) there are not many other design factors to avoid when asking for moulds made by the new process. He finds it possible to make a fully cored and cooled mould in Tandium with a minimum wall thickness of $\frac{1}{8}$ in—which is as low as most people would demand.

Vinamold compounds are supplied by Vinatex Limited, Devonshire Road, Carshalton, Surrey.

Estimation of Costs (Mr. Young)

For making one half-mould for jug about 6 in long with undercuts as shown in top illustration.

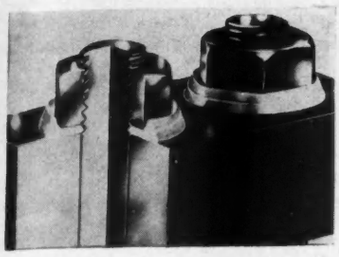
	£	s	
Machined from block aluminium			
Hand make wooden model of mould, 50 hr at £1	50	0	(S)
Copy on Keller machine, 30 hr at £2	60	0	
Finish off and fit tubes, 60 hr at £1	60	0	
Total cost: 1 off, £170 each; 10 off, £125 each			
2 Cast from pattern			
Hand make pattern of mould with prints, 50 hr at £1	50	0	(S)
Make sand mould and cast metal	8	0	
Finishing off, 25 hr at £1	25	0	
Total cost: 1 off, £83 each; 10 off, £38 each			
3 Cast by new process			
Hand make wooden model of article, 12 hr at £1	12	0	(S)
Make Vinamold mould surrounded by plaster, including materials	5	10	(S)
Make plaster model	2	0	
Make core box and wooden shell pattern for foundry use	15	10	(S)
Bake plaster model and cast metal	11	0	
Finishing off, 4 hr at £1	4	0	
Total cost: 1 off, £50 each; 10 off, £20 7*s* 6*d* each			

(S) indicates those items of cost which are shared where more than one mould is required.

Nylon Washers Hold Nuts Tightly

A bad nut-loosening problem is claimed to have been solved by using nylon washers which bed down as shown in this illustration.

After installing a sub-station for J. Mountford and Company, the North Western Electricity Board was faced with nut and bolt loosening on the transformer. This was situated close to drop forging plant. Fan Disc, who make nylon washers under the name of Dubo retaining rings, say that various locking methods were tried



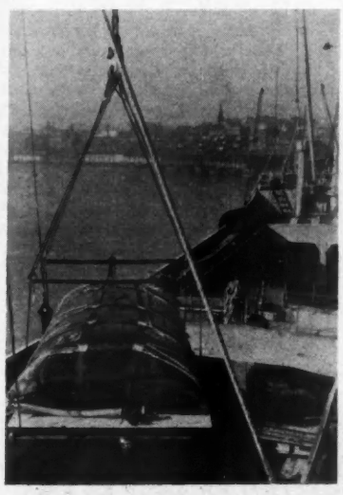
without success. They add that use of Dubo rings proved completely successful in that no maintenance has been needed for six months, whereas previously it had been necessary to retighten the nuts and bolts at about three week intervals. Note, say Fan Disc, how a tightened ring provides four-way grip: friction against the but and bearing surfaces, friction against the thread, and tab action against the flats.

J. Mountford and Company are also reported to have nylon rings under test on the actual drop hammers where similar vibration problems exist.

Fan Disc Limited, 109 Northwood Street, Birmingham 3.

Another Maker of Collapsible Containers

Since our article on collapsible containers was published in ENGNG., 3 March '61, pp. 310-11, Marston Excelsior have pointed out that they also have several industrial users of their own



variety of tank from whom we could have obtained comments. This company's containers are called Portolite and the illustration shows a 1,600 gallon one on a pallet being loaded into a ship's hold. The tank was carrying Butakon latex (made by a division of ICI) to Sweden.

Portolite tanks are made from one of several combinations of fabric and rubber coating. For instance there is rayon covered by Hycar nitrile rubber, Terylene covered by Hycar, rayon covered with butyl rubber, and Terylene covered with butyl. The standard range of standard construction extends up to 5,000 Imp. gallons but they have also made them up to twice this capacity.

Marston Excelsior Limited, Fordhouses, Wolverhampton.

Nylon/Cotton Conveyor for NCB

A conveyor belt supplied by BTR Industries to the Pit House Drift installation of the NCB is now said to have handled over 350,000 tons absolutely trouble-free. It was installed in June 1960.

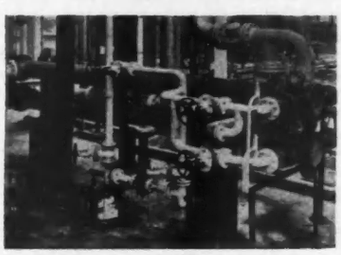
The belt is called Tuftex and incorporates BTR's unusual reinforcement. This consists of continuous nylon filament warp and weft members with a cotton cover in the warp. As supplied to the NCB, three ply construction was used with a breaking stress claimed to be over 6,000 lb per in width. Maximum working tension is a tenth of this figure.

At Pit House Drift the belt was vulcanised on site from four lengths, but this belting can also be joined with fasteners. A 3 ply belt with fasteners can be operated at 440 lb per in width, say BTR.

BTR Industries Limited, Herga House, Vincent Square, London SW1.

Aluminium Cooler Performs Well

An aluminium heat exchanger with an aluminium alloy lining (which acts rather like galvanizing on



steel) has performed well during its first year in service. This is reported by Alcan Industries who supplied the metal.

The unit, made by the heat exchange division of Wellington Tube Works, was installed in the gas purification plant of Mobil Oil Company's refinery at Coryton. Here it was found after service that it had resisted the attack of hydrocarbon gas containing 10 per cent hydrogen sulphide and a trace of water vapour which passes through the shell side at 220° F. Also it has withstood the corrosive properties of Thames Estuary water which is passed through the tubes at 6 ft per sec. Some light pitting found on the outside of the tubes is attributed by Alcan to carry-over of rust particles from other parts of the plant.

The Noral 3S alloy tubes for this cooler are internally lined with Noral 72S. 72S is a 1Zn-aluminium alloy and is anodic to the 3S under these operating conditions so that it protects the outer tube sacrificially like galvanizing.

Alcan Industries Limited, Banbury, Oxon.

Cold Casting "Metal" for Models

Vinatex have arranged for their flexible mould-making compounds to be sold together with a metal-filled polyester compound. Both can now be obtained from Alec Tiranti Limited as a "cold casting" system.

The idea of filling polyester resins with fine metal powders is not new, as there is at least one other firm who offer this product. However, the moulding compounds offered by Vinatex make their use very easy. Vinagel is a plastic material like Plasticine which will set hard when heated after moulding to shape. This model—or one made from plaster or wood—is then placed in a box and one of the hot-melting Vinamold compounds poured around it. When set, the flexible mould can be removed and used directly for casting epoxy, phenolic, polyester or metal-filled polyester into it to get the final object. The Vinagel will not soften once hardened, but the Vinamold can be used over and over again so long as it is clean before being remelted. This illustration shows a giant-size display model made by C. F. Taylor (Plastics) from polyester resin with glass fibre reinforce-

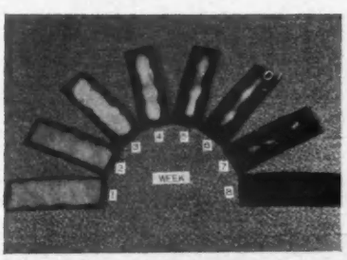
ment. This was laid up (rather than cast) in a Vinamold mould made from a four part wooden model.

Alec Tiranti Limited, 72 Charlotte St., London W1.
Vinatex Limited, Devonshire Road, Carshalton, Surrey.

Impregnated Timber Available in UK

Borax Consolidated have worked in liaison with the Finnish company called Rauma-Repola Oy to have imported timber impregnated with a preservative. This preservative is a soluble sodium borate, called Timbor by the makers. It is applied by dipping freshly cut timber in an aqueous solution of the chemical which subsequently penetrates right into the centre.

The illustration shows penetration of the chemical into 6 in by 2 in Redwood. The colour is



that of a dye used solely for testing penetration.

Borax Consolidated claim that this treatment offers complete protection against dry rot and insect damage without any change in colour or properties. Cost is only a few per cent more than when untreated. Stocks of Timborised timber will be held by May and Hassell at Boston (Lincs.), Birmingham, Poole, Bridgwater, Cardiff, and Liverpool, R. Wade, Sons and Company at Hull and Grangemouth, and Parkers (Ancoats) at Manchester.

Borax Consolidated Limited, Carlisle Place, London SW1.

Use and Abuse of 3-D Model Layouts

Used selectively, three dimensional models can be a useful tool for the methods or planning engineer. They also provide a useful basis for discussion where decisions must be agreed by people who are unable or too busy to read engineering drawings.

METHODS and planning engineers have long used two dimensional models, or "cut-outs," to assist them in drafting and developing shop and factory layouts. Now, it seems, there is an increasing tendency to use three dimensional models instead and, in many cases, this development has simplified the work of the methods engineers, both in clarifying their own ideas and in obtaining constructive criticism from the people who will have to manage, operate and maintain the final layout. There may, however, be a temptation to eulogise these fascinating miniature facsimiles of real plant—Robert Morley's characterization of a model-struck managing director in "The Battle of the Sexes" is sometimes uncomfortably close to the mark.

As an argument against the trouble and expense—if trouble and expense, it is—of employing three dimensional models, it is sometimes said that the normal single storey engineering shop, for example, can be laid out effectively with two dimensional models. It is true that cut-outs attached to pressure sensitive double-sided tape, as made by Ozalid, can be moved around easily and repeatedly so that prints can be taken of alternative layouts before a final decision is taken. It is often true, too, that the engineer on a factory layout project is closely enough acquainted with the plant to make necessary allowances for machine projections, headroom, movement of operator and materials, and servicing piping and wiring.

What is not necessarily true, however, is that the people with whom the methods engineer must discuss his ideas—the board (in the case of a small firm or a big application), the works management, foremen, shop floor personnel, maintenance staff and, sometimes, constructors—will also visualize the full layout from cut-outs in the same way as the methods engineer who has been living with his ideas for weeks or months. Some of these people will not be trained in the interpretation of engineering drawings, and a two dimensional layout or drawing will not come to life for them in the same way as would three dimensional models.

A non-engineer board member who cannot read a drawing well enough to understand the full implications of particular proposals might well have any lingering doubts removed if he can have the set-up demonstrated to him three dimensionally. In the same manner, a shop floor operator might be unmoved by a line drawing but encouraged to make useful suggestions if he sees the same layout in model form.

The second argument for cut-outs, that the planning engineer can be relied on to make allowances in the third dimension, is not always watertight. It is not unknown for plant to be actually installed before it is discovered that there is insufficient headroom to operate an overhead crane or to bring in plant scheduled for a later stage of installation.

If it is difficult to generalize on the advantages to the methods engineer of using models, there seems to be no doubt about their usefulness as training aids. Indeed, firms who introduce model layouts as a planning tool almost invariably retain them as instructional models in their training school or department.

Fig. 1 A model layout under construction at T. H. & J. Daniels Limited.

CASE IN POINT

An example of the effective use of a model layout as both a planning tool and a training aid comes from T. H. & J. Daniels Limited who make hydraulic presses, vacuum forming and injection moulding machines, and other plant at Stroud, Gloucestershire. Recently, they have been reorganizing their overall layout with the addition to their factory space of a 22,000 sq. ft assembly shop. For each department and shop, the work study department have drawn up a complete $\frac{3}{8}$ in to 1 ft scale model layout (one of them is shown in Fig. 1) which has been fully discussed with the management, the shop superintendent, the section foreman and the individual operators.

Criticisms have been received from all levels and have been carefully considered by the work study engineers. Not least important have been suggestions from the operators about slight repositioning of machines to avoid sending sparks or swarf flying in the direction of other operators. These might seem small points but it is obviously better management and better economics to have them hammered out on a model than on the shop floor after the plant has been installed. Having been brought into the picture at the planning stage and been encouraged to experiment with alternative layouts on the model, both management and operators make a contribution to the final layout and see themselves as sharing responsibility for making it work.

Once all suggestions have been considered, the model is "frozen" and becomes of interest to the plant engineers who are to effect the installation and to the electricians and others who are to provide the services. Using the model as a demonstration unit, the work study engineers have been able to coordinate the activities of the production personnel, the plant engineers, the services engineers and, where appropriate, the builders, to make the necessary changes with a minimum loss of output.

After the model layouts for each department have completed their planning job, they are passed to the apprentice training school where they are used both for apprentice training and for induction and method study courses.

Another firm which is a keen advocate of the use of models in planning factory layouts is Simon Engineering, of Stockport. They have a full-time model-making section producing detailed models of factory layouts and of individual machines. The Dunlop Advisory Service Limited is also very experienced in the use of factory planning models.

COST

The objection to three dimensional models on grounds of cost is probably weaker than many engineers think, at least for simpler and more common plant such as machine tools. Firms such as Visual Planning Systems, of Wembley, and Industrial Models, of Ashton-under-Lyne, quote lower prices than one might expect. Fig. 2 shows a model layout of a cigarette making and packing factory made for the Molins Machine Company Limited by Visual Planning.

Where working models are required, as distinct from scale non-working models, FAC industrial construction kits (marketed in this country by Weyco Sales Limited) provide a versatile basis.

Engineers have sometimes found that when models of whole factories or departments have to be specially made—as distinct from individual models which are laid on a gridded base to represent the shop floor—the cost becomes of a very different order. A model of a complete brewery made for Production Engineering Limited, in connection with a current project, cost something over £500. This figure looks slightly less shattering when one takes into account the fact that this is for a big brewery costing £3¼ million. When ICI build a "Final Piping Design Model" for a new processing plant they reckon an average cost to be something like 0·25 per cent of the plant cost.

However, to the low budget methods engineer it might be reassuring to know that some people use home made models successfully. At the Cranfield Work Study School, where embryo work study engineers are taught to operate on a shoe string, models of the type shown in Fig. 3 are made cheaply and quickly from balsa wood. These might not compare in detail and finish (they are not meant to, of course) with commercially obtained models, but they are often of real practical use and any important clearances can be shown by pins stuck in the balsa wood.

CONSULTANTS' VIEWS

Most of the member firms of the Management Consultants Association use three dimensional models for training purposes—and find them very effective—but they have varying degrees of enthusiasm for their use as factory planning tools. Indeed, on balance, consultants seem to place less store than methods engineers within factories in the efficacy of models for this purpose. This might be because their developed expertise in dealing with fresh problems and, therefore, reading drawings quickly and readily makes them adept at appreciating layouts from cut-outs, or it might be a warning to the dinky toy fans among methods engineers that some applications of models are more gimmick than necessity.

At Production Engineering, for example, where there is a comprehensive factory planning service, consultants in the field have the backing of model making facilities but tend not to use them as an aide in their own deliberations. In the method study stage they normally use cut-outs and, where necessary to illustrate clearances between machines or between a machine and an overhead obstruction, elevation drawings. When they have arrived at their conclusions they might then draw up a model layout in order to illustrate their proposals to the client firm. In other words, they find two dimensions enough for the majority of their own analyses but occasionally use the third dimension to put their findings across to the client board of directors.

Personnel Administration Limited, too, find that putting proposals across to the client is a major use of three dimensional models. How-

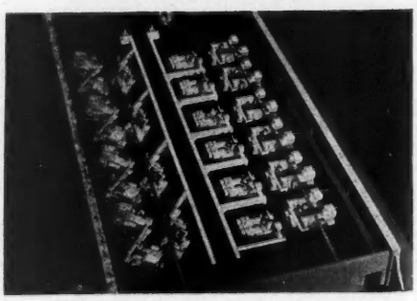


Fig. 2 Model cigarette factory made for the Molins Machine Company by Visual Planning.

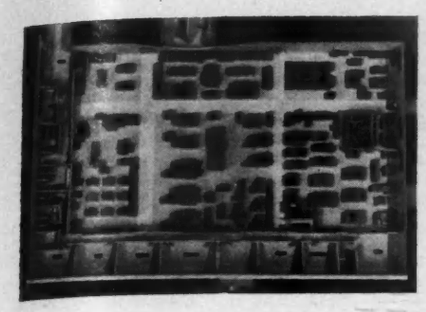


Fig. 3 A "home made" balsa wood model made at Cranfield for the Perivan Group, Southend.

ever, they also insist on putting models in perspective as being one of three types of visual aid—the others being drawings and cut-outs—rather than an end in themselves. Sometimes they use a combination of these aids in the interests of speed and economy. Thus, in a large printing works at Aylesbury they used a perspex sheet multi-storey type of model structure frame but, on each floor, used cut-outs for the plant.

As well as finding three dimensional models useful for demonstrating or selling their ideas to clients (a similar relationship to that of the methods engineer dealing with his own management and shop floor) Personnel Administration sometimes use them for their studies in, for example, modifying old or complicated buildings which are so rambling that they are difficult to visualize as complete buildings. Again, when laying out plant for a projected new building, this consulting firm like to establish the basic flow lines before the building plan is finalized. This entails close cooperation with the architects (and, later, the tendering firms), and such co-operation is often easier if the flow lines and plant can be seen in model form.

Urwick, Orr and Partners, also of MCA, use models effectively for factory planning and, on an impressive scale, for training purposes. At the Urwick Management Centre there is a three dimensional model (now used for training, but originally devised on a project in the field) of the delivery end of a granular material plant which has been improved radically. Originally, the material was bagged at the end of the production process and then de-bagged, where necessary, to meet customer bulk orders. By drawing up a fresh model layout, it was possible to redesign the storage and despatch area so that the main store became a bulk store and any bagging was done against customer order only. The use of the model was instrumental in making a saving of some £30,000 in capital expenditure.

Other layouts made at the Urwick Management Centre include farm exercises and one designed to show how materials, men and services can

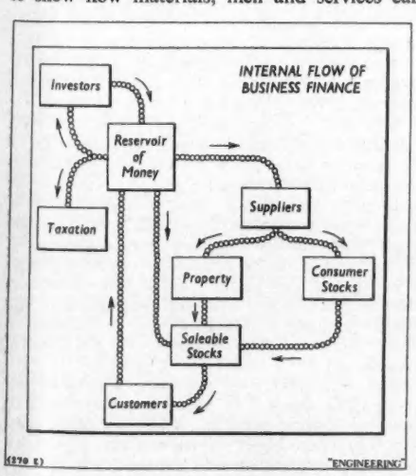


Fig. 4 A conceptual model used at the Urwick Management Centre. Moving lights indicate the flow of money.

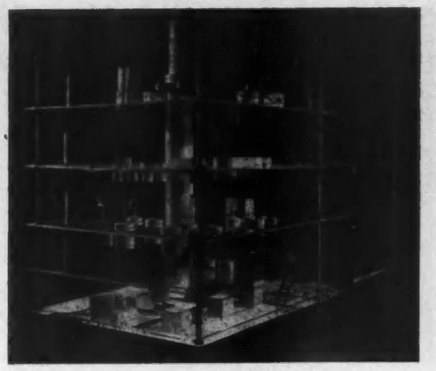


Fig. 5 A typical processing plant preliminary model by Industrial Models.

best be deployed during the development of a building site. In this example, some of the scale models of contractors' plant were bought from the shelves of a toy shop, another reasonably cheap source of models. The *pièce de résistance* is a model of a complete single storey factory, known to management course members as Messrs. Wropersons, which is used in conjunction with a two day exercise on every aspect of management. In teaching the principles of factory layout, incidentally, the Centre has a useful maxim—"If it looks right with just the men and the machines in, it's wrong, because there can't be room for the materials and handling equipment."

Interesting work has also been done recently at the Centre on full size mock-ups or models of bench layouts. From this work new principles are being evolved on operator hand movements (some of them learned from the study of ergonomics), the emphasis now being on "sympathetic" rather than "symmetric" movements. Indeed, by discarding the theory that simultaneous and symmetrical hand operations are the most efficient, a 36 per cent improvement has been obtained on a bench layout that was thought to be the ultimate in efficiency a few years ago. Even in bench layouts, it appears, "there's always a better way."

At the Urwick Management Centre, one is reminded, too, that models can be conceptual as well as facsimiles. In Fig. 4 is reproduced a conceptual model which is used to give life to the mundane subject of business finance. Similar models are used to demonstrate facets of company organization.

PROCESSING INDUSTRIES

If there are divided opinions about models being an effective planning tool in engineering and assembly shops, there is no such division of opinion about them in the processing industries where they have effected outright economies as well as producing a higher quality end product than was possible with drawings alone.

Typical of models produced for multi-storey processing plants are those built by Industrial Models Limited, an example being shown in Fig. 5. The floors are represented by perspex sheets separated by metal rods and detachable to permit rearrangement and detail work.

The technique of using models has arisen in processing largely as a result of method studies of the whole system of developing schemes from the design stage and through factory planning and manning to inviting tenders and instructing construction engineers. It has been found, in fact, that they can provide a quicker and cheaper means of communication between these stages than is possible in two dimensions.

In ICI, for example, it is no longer the common practice to go through the tedious business of making a series of alternative general arrangement drawings at the outset of a scheme for a new plant. Instead, the process begins with a flow sheet which is virtually an elevation of the essential hardware, or vessels, in the scheme. These vessels are linked as necessary, but, at this

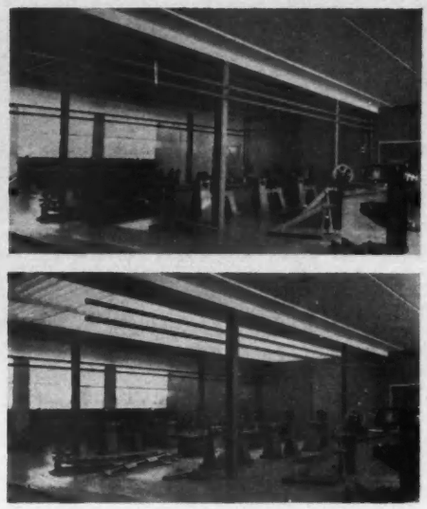


Fig. 6 An experiment in permanent supplementary artificial lighting at the Building Research Station, (top) with side windows only and (bottom) with by p.s.a.l. (Crown copyright reserved.)

stage, the arrangement is essentially a basis for experiment and not a possible final layout.

By a technique for determining the relative priorities of relationships between the various vessels, the possible layouts are then reduced to as small a number as possible. This technique is vital since the permutations of vessels and floor levels in a large plant can run into millions.

When the alternatives have been reduced in theory to two or three, this number of preliminary models is then built. These models are of flexible design and are discussed with designers, chemists, engineers and many other people, such as safety officers, who can offer stimulating advice but might not be able to read line drawings. After the preliminary model has been agreed, the final piping design model is then built to include piping, ducting, valves, fittings and instruments. At this stage, when hundreds of pipes might be involved, the advantages of having a third dimension become yet clearer.

Once the final model has been agreed it might then be necessary to produce detail drawings by separating the floors but, even here, there is increasing use of photography to obtain piping details and thus reduce drawing office costs still further. Apart from these costs, however, the model provides an opportunity of anticipating many of the operational and maintenance difficulties which can bedevil a new plant.

In addition to the more orthodox uses of models a specialized use has been in the work carried out at the Building Research Station, Watford, on the use of permanent supplementary artificial lighting. Models have been employed, as shown in Fig. 6, to ascertain how supplementary light can brighten apparently darker areas and make them look as bright as the rest of a department, without interfering with the essential character and direction of the natural daylighting. The development of large and high density building is making this an important study.

CONCLUSIONS

It would seem that the case for using models is proven in the processing industries on grounds of both economy and quality. In the engineering manufacturing industries, too, they can be used, and have been used, to good effect. It is important, though, to recognize them not as ends in themselves but as one of the means to the end of producing a final layout that is the best in a given set of circumstances and, equally important, can be demonstrated as such to engineers and non-engineers alike.

The essential criterion must be that the methods engineer should apply his method study techniques to his own approach to each individual factory planning application.

On the Shelf

By Frank H. Smith

SOME years ago, I tried to flog a perfectly good piano for about £9. Early in May one of my sons presented his younger brother with a piano—he had paid £2 for it at a jumble sale! For librarians, secondhand booksellers' catalogues have much the same fascination as jumble sales have for the wider public (which includes the librarians, because there's always a book stall. I was in charge of one and could not sell books at 12 for a penny—apart from an illustrated Rabelais). Deighton Bell and Company Limited, 13 Trinity Street, Cambridge, have just issued their list No. 8 and, as you know, university towns produce a fine crop of scientific and technical bargains.

In a recent review (ENGNG., 10 Mar. '61, p. 364), D. B. Welbourn bemoaned the lack of a glossary of English and German mathematical signs. Almost before the ink was dry, C. T. Rivington, managing editor of Blackie and Son Limited, drew our attention to Vol. 40, Winter 1956, No. 4, of the *The Monotype Recorder* where an article "Setting Mathematics" contains a quite good glossary of mathematical signs. But surely to goodness there is not all this lack of such glossaries? Does Mr. Welbourn mean English into German? He does say "in English or in German." The newer science of aeronautics has its sources for such signs and I cannot think that mathematics can be lacking. I will now sit back and wait for the avalanche. My own contribution is *Scientific and Technical Abbreviations, Signs and Symbols*, by Zimmerman and Lavine (Industrial Research Service, Dover, New Hampshire, 1948), and "*Monotype*" *Mathematical Sorts List*, selected and compiled by Arthur Phillips (Monotype Corporation Limited).

I know there is no need for me to apologise for mentioning bibliographies in any shape or form. A juicy long one is available from HMSO at 12*s* 6*d*. It is the Science Museum's *Books on the Chemical and Allied Industries: a Subject Catalogue of Books in the Science Library*. Books, you'll notice, only and it runs to 118 close-type pages. Another less voluminous but more specialized bibliography comes from the City of Birmingham Public Libraries on *The Manufacture of Non-Ferrous Seamless Tubes 1939-60*. No visible charge this time.

From time to time I have mentioned the *Occasional Papers* of the Graduate School of Library Science, University of Illinois, Urbana, Ill. It is a matter of luck whether or not any of these happen to be of immediate interest to you, but there always is that chance and I think nobody can grumble at the two dollars a year they now find they must charge for a guaranteed minimum three papers a year. Single copies a dollar.

Purveying periodicals is evidently a competitive occupation, and a list of all those who issue catalogues of their rates would stretch from here to there, providing nothing got in the way. W. H. Everett and Son Limited, of 10 Friar Street, Carter Lane, London EC4, must have waited 73 years before they could quote a rate for the Best Weekly for they were founded in 1793. Their foreword is an extract from a testimonial from R.L.S. writing from Samoa.

I am so keen on Clean Air that though I do not live in a smokeless zone I burn some stuff that costs much more than coal and never shows a flame. I am impelled, therefore, to mention *1961 Clean Air Year Book* at 2*s* 6*d* from National Society for Clean Air, Field House, Breams Buildings, London. EC4. Were I addicted to puns I would say that this annual breathes the very spirit of clean air, but its sponsors certainly do everything they can to make our atmosphere breatheable, and they are another of those bodies that have grown from cranks to prophets and from prophets to messiahs.

Science and the Human Element

Decisions, Values and Groups. Edited by DOROTHY WILLNER. Volume I. *Pergamon Press.* (80*s*)

Notes on Operations Research. Assembled by the Operations Research Center, M.I.T. *Crosby Lockwood, London.* (30*s*)

Science continually extends its boundaries. Optical microscopes and optical telescopes were for long the symbols of its penetration into the unknown. They have given way now to the electron microscope and the radio telescope; but this is readily seen to be "progress," for the framework of discovery remains unchanged. The new symbols are acceptable too. Outside the classical framework of research, however, all kinds of conceptual difficulties are met by those who observe the amalgamation of sciences in pursuit of unorthodox ends. Even scientists themselves are susceptible to thought blocks, and cries of pain were heard in distinguished places as minds boggled at the very idea of space exploration. No one knows the escape velocity of thinking through a thought block, but doubtless many of those were ruptured as Gagarin and Shepard were flung into the weightless void.

Probably the greatest psychological barrier of them all is encountered when science meets human behaviour. People do not think that they themselves can be accounted for; they do not want to be explained—it is only a step from being explained *away*. And so, whenever the scientist has to deal with a situation involving men and women, he becomes an object of suspicion, derision or reproach. These attitudes seem traceable to a mixture of fear and pride; but they can readily be dressed up, today as in the time of Socrates, in a falsely humanitarian garb. When it is difficult to agree with a scientist's logic, or his handling of statistics, it is beguilingly easy to dismiss him as perverse or wicked.

We ought not to imagine that men working in the so-called "behavioural sciences" are necessarily denying the status of beauty and goodness in their search for truth, nor that operational research men who talk of the "science of management" are necessarily denying its arts. Is the biologist who tries to understand the photosynthetic process by which an autotrophic plant utilizes solar radiation thereby making its flowers less beautiful? Scientifically to understand something about the decision process of a manager, or about the interactions of people in a group, does not rob mankind of free will. There is no need to panic.

Decisions, Values and Groups is a book of behavioural science. This might be explained as an attempt to endow the study of "the human element" with verifiable operational content, in place of verbal speculation about "the mind"—which cannot be seen, touched, smelt, heard or tasted. The mind is a word referring to a non-extensive correlate of the brain that directs activity. Scientists find that they can directly observe both the brain and the activity, and see these as topics of legitimate scientific study. And who shall blame them?

Mr. Arthur Koestler does, for one. Writing recently in *The Observer* (7 May '61), he declares that "a new era is in the making—not in the 'Behavioural Sciences,' that castrated version of psychology, but in the study of the mind." It seems fair to quote this alternative view here, though we might think that Freud ushered in that particular new era sixty years ago. (It is interesting to wonder what the founder of psychoanalysis would have made of Mr. Koestler's metaphor too. There is no need to panic.)

This book, then, incorporates the attempts of groups of scientists to talk sense about the notoriously difficult problems generated by the human element. The first part deals with decision processes, and offers various mathematical models of what fundamentally is going on when decisions are taken. But decisions are not simply based on comparisons of statistical chances; modern work clearly recognizes that they incorporate value judgments. Can science penetrate these mysterious processes too? Part 2 consists of a second group of four papers tentatively examining this question. One goes so far as to consider a plan for investigating the structure of conscience.

So far the work reported has been largely oriented upon the individual. But one excellent way of examining this class of problem is to study a small group of people engaged upon a common task. The ways in which the individual in the group cooperates or not, leads or follows, communicates, identifies, and so on—these are the topics of the next set of papers. Nothing startlingly new emerges, perhaps, at least for those who are familiar with this kind of work.

What is important here is the way in which an interdisciplinary approach to such matters is cautiously building itself over the years. In real life people flatter themselves that they fully understand what makes a society tick. Nonetheless, the "organization man" has arrived to trouble our consciences and companies; and bitter frustration for the individual coupled with tiresome inefficiency for the group is almost an accepted part of "civilised life" today. Inquiries such as these, patiently constructing a framework within which such larger problems will one day be scientifically and helpfully discussed, are therefore exciting.

In its fourth part the book turns to psychodynamics. There is for instance an interesting account of hostility, and another of depression. A postscript deals with a couple of military problems: one concerns motivation, and the other talks topically and brightly about the human element in space.

In sum, this is a readable book which makes an excellent introduction to the scope and method of behavioural science. It was sponsored by the American Air Force, who called a conference of 32 specialists in diverse fields to undertake an eight-week work session. The book is the result of their labours, and the style is inevitably uneven. But there is nothing esoteric about it, and the "jargon index" is unexpectedly low for this kind of volume. Only one paper involves sophisticated mathematics, and even this should be comprehensible in intention to a reader who skipped the symbolism. Useful references are appended to each paper, but there is no general index.

The book just discussed concerns somewhat academic research. The practical, day-to-day version of the attack by interdisciplinary science on problems involving the human element is operational research. In this, the problems of management strategy come under review. This time the object is not to throw general light on the subject, but to treat of decision processes and value judgments in the context of actual groups with actual difficulties to resolve. This is the behavioural science of governments, industry, and business, and it has to produce answers: answers that work, now.

In *Notes on Operations Research* the OR research centre at the Massachusetts Institute of Technology has assembled a dozen papers on the mathematical techniques of the subject—all written by workers of international repute. It must be said at once that readers who cannot cope with mathematics cannot read this book. This is not, as some misguided people imagine, because OR is "really" applied mathematics, but because it is a scientific pursuit—and the basic language of science is mathematical. Here there is no concession to the general reader.

But, for those who can cope, this is a very remarkable book. In Britain, we are used to massive American tomes, which we often criticize for unnecessarily diffuse writing. This book is admirably precise and pointed. It is even cryptic, and may not be comprehensible to the completely uninitiated. However, it is called *Notes*, so there is nothing misleading about

that. In fact, this is just such a volume as an OR man might have compiled in his own notebooks, and it makes a handy refresher course.

There is a chapter of notes on probability theory beginning with relative frequency, running through Bayes' theorem and distribution functions to difference equations. This section is followed up later by a separate chapter on Markov processes. These processes form a background for a treatment of techniques which have originated specifically in the OR context—the theories of search, queues, reliability and maintenance, scheduling (linear and dynamic programming), and simulation. The cognate subjects of control processes (the systems analysis approach) and information theory are also covered. The only notable omission, then, seems to be the theory of games.

In all cases pithy examples are sprinkled through the text: not the usual mammoth (and apocryphal?) "case histories," but clear little statements of the kinds of situation in which the theoretical work becomes relevant. Two pages only are devoted to the thorny topic of organizing OR, but Professor Morse does a crisp job and makes the vital points. For example: "The director of [an OR] group reports directly to the Assistant Chief or Staff for Operations, . . . is able to talk . . . with the Chief of Staff of the Service and is able to sit in on various high-level planning conferences." Here is military OR with a lesson for industry.

References take the form of a (sensibly) select bibliography, and there is a rather brief index. These *Notes* are written by professionals for professionals, who should find them useful. Others may be surprised to see just how far science has gone towards mastering the problems of large and complex systems, in which chance, mischance and the human element play commanding roles.

As a final word of encouragement to those who fear that man is likely to be dehumanized by scientific research of this kind, I can say from personal knowledge of some of the authors of both books that they are not people who wish to degrade "the human element" to the status of clockwork under random perturbation. This idea (*pace* Mr. Koestler) is out of date. To quote from the Introduction to the first book: "Modern decision theory departs from the conception of mechanistic determinants of action and frankly posits a 'rational indivdual'." That is a distinguished behavioural scientist, Dr. Anatol Rapoport, speaking. Anyone who thinks he is likely to have a crude, mechanistic approach may give themselves the privilege of reading his preface. And anyone who thinks that such a profession must make him insensitive to the finer things of life should (if they ever get the chance) give themselves the pleasure of hearing him play Bach.

STAFFORD BEER

Ear Defence

Noise Reduction. Edited by LEO L. BERANEK. *McGraw-Hill, New York and London.* (112*s* 6*d*)

The study of sound, under the title of Acoustics, has for many years been the Cinderella of the physical sciences. Now, after a long period of obscurity, sound research is re-emerging as the Ugly Sister, Noise Control. This transformation is well advanced in the United States of America and in Germany where the demand for information has led to the inauguration of semi-technical magazines which are devoted exclusively to noise and its control. United Kingdom interest in the subject is evident from the decision to hold a three-day conference on Controlling Noise at the National Physical Laboratory from 26 to 28 June.

In this country, the attitude of the engineering industry to noise has undergone a subtle change during the past decade, in that noise is now acknowledged as being undesirable. During the next ten years, the change will continue and be more radical since noise levels will require to be reduced.

The public reaction to aircraft noise has already ensured that noise must be a primary design consideration in future aircraft which are to operate near centres of population. With increasing traffic densities, the noise from motor vehicles is now attracting unfavourable attention. Manufacturers of products sold to the general public have realized for some time that quiet products have sales appeal. The increase in the use of office machinery has produced a demand for quieter operation. Finally, the realization that prolonged exposure to noise at high levels can produce a permanent hearing loss is generating a demand for the control of noise in its traditional home, the industrial workshop.

All these trends mean that the control of noise is a new problem for the design engineer, the production engineer, and the plant engineer. For this reason, any book entitled "Noise Reduction" is likely to attract more than a passing interest. This particular book has been developed from a series of lectures presented at a special summer course on the subject given at the Massachusetts Institute of Technology.

There are four sections dealing with sound waves and their measurement, fundamentals underlying noise control, criteria for noise and vibration control and practical noise control. The various chapters are developed from the original lectures prepared by a number of individuals and have been edited by Dr. Beranek who is also the principal contributor. As president of the consulting firm of Bolt, Beranek and Newman, and as a world authority on acoustics, Dr. Beranek is well equipped for his task and the result is entirely satisfactory. There is an inevitable variation in style but the terminology is uniform and there is the advantage that each chapter is largely self-contained.

The aim of the original lectures and of the book is to present the fundamentals of noise reduction to engineers who are not specialists in acoustics. In this it succeeds very well and is much more than a mere introduction to the subject. It may be regarded as an up-to-date statement of the extent of knowledge in the field and with its extensive bibliography may be used as a starting point for further study. Most of the references are to American work but it should be recognized that the Americans have put much more time and effort into this subject than the British. Although the section on measuring equipment refers to instruments available in the American market, the principle of the various procedures is dealt with in general terms which makes the section valuable to British readers.

Altogether, this book is an excellent testament to the ways in which the acoustician has attempted to assist the engineer with his noise problems. It shows clearly the way in which acoustical materials and techniques can mitigate the effects of a noisy machine. It also shows that with adequate measuring equipment, it is possible to state the problem and assess the value of any noise reduction measure. From this point of view it is of particular interest to the architect and to the plant engineer.

It also shows quite clearly that if the noise of the machine itself is to be reduced, then the engineer himself must take up where the acoustician leaves off. Dr. Beranek and his colleagues provide the basic information which the engineer requires to face his problems with confidence.

G. BERRY

Low Energy Rupture

The Brittle Fracture of Steel. By W. D. BIGGS. *Macdonald and Evans.* (70*s*)

Professor E. Orowan of the Massachusetts Institute of Technology has said that brittle fracture is the most frequently rediscovered phenomenon of the 20th century. In its many guises, low-energy fracture of nominally ductile materials had already been taking place for a long time in an unobtrusive way before it appeared in epidemic proportions in the all-welded ships built by the United States during the Second World War. The large-scale research programme that followed turned up several of the now well-known features of brittle fracture of mild steel and thus pointed to possible alleviatives. The resulting improvements in ship design, steel quality, and welding were formalized in the USA shortly after the war.

From the practical point of view, with the hindsight of the ensuing fifteen years as a sure aid, the problem of major fractures of US-built merchant ships was thus solved: no US merchant ship built since the above improvements (which have later been further modified) took effect has suffered a major structural fracture. However, each year several more wartime-built ships fracture, in spite of measures taken to make them safer; the problem in these cases is that, unless the hull structures are fundamentally altered or superseded, a certain small fraction of the ships will fail under the extreme conditions of low operating temperatures and severe loadings.

In spite of the above costly experience, the quasi-brittle nature of mild steel was still not well known in the early 1950's. A spectacular event then served once again to inform another group of the nature of the problem. Within a period of two weeks two newly completed oil storage tanks in England broke completely apart. Thus the oil companies became concerned with this problem and the US owner of the English tanks sponsored a fine *ad hoc* research programme which added considerably to the understanding of brittle fracture.

Then, when the matter had quieted down again, two tankers in the 20,000 to 60,000 ton range which had been built in different countries in the 1950's broke in two. Although both were subjected to admittedly severe and unusual loading conditions, their brittle behaviour must have surprised many people, including their designers. That some people are still stunned may be inferred from the absence of a full report of either fracture.

Low-energy fracture has cropped up more recently in, for example, the failures of alloy-steel turbine-rotor forgings and of very high strength thin-sheet rocket motor casings. In these cases someone, either the material producer, the fabricator, or user, poured money into a quick research programme directed toward an economical solution to his problem. As soon as his problem was under control, even though the fundamentals of brittle fracture may not have been examined, the research was terminated.

During the period since the Second World War at least two groups have maintained continuing interest in a better understanding of brittle fracture: the Admiralty Advisory Committee on Structural Steel (successor to the Admiralty Ship Welding Committee) in the United Kingdom and the Ship Structure Committee in the

United States. In virtually every new instance of brittle fracture known to this reviewer, one or the other of these groups has provided information to the newcomer that has aided him in better comprehending his problem. This ability to assist in time of need has resulted from the continuing nature of the programme; the Ship Structure Committee (with its early predecessor, the Board of Investigation), for instance, has sponsored research projects in the field of brittle fracture for eighteen years. As many phases of the fundamentals of this problem are still only little understood, interested and concerned groups around the world are currently conducting research programmes directed toward better comprehension of the basic mechanisms of fracture.

Dr. Biggs' book, a first edition, will therefore fill an important need in the education of anyone facing for the first time the problems of the use of brittle or quasi-brittle materials, and will at the same time be of interest to those who already know something about these matters. The book describes in an easy style the historical background of service failures and related research studies and then delves into the current state of knowledge of fundamentals of fracture. The ubiquitous but probably necessary description of standard and special tests is also included.

The author ends his brittle-fracture presentation with a well-balanced discussion of the influence of metallurgical variables on material behaviour and how welding can influence microstructure, but then he tacks on an inconclusive chapter on residual stresses which may leave many readers up in the air (perhaps as the author has intended). As many researchers today believe that residual stresses contribute no more to brittle fracture than sharp knives do to crime, it is unfortunate that the author has devoted an entire chapter to the subject.

Readers already acquainted with the field of brittle fracture will understandably want to compare this book with the 1957 book of Professor E. R. Parker, *Brittle Behaviour of Engineering Structures*. In addition to containing material that has become available since Professor Parker's manuscript was completed, Dr. Biggs' work has a different stated purpose. Rather than presenting a summary of current information on brittle fracture, the present book attempts " to reconcile, as far as possible, the differing approaches made to the problem of brittle fracture by the engineer, the metallurgist and the physicist . . ." (from the preface). Now this is a formidable task to set one's self, but the author has presented the full range of knowledge of brittle fracture about as fairly as appears possible, amidst the current jungle of concepts and nomenclature, so that neither the engineer, metallurgist, nor physicist is likely to present significant disagreement.

Because a book such as this can serve as a springboard for the reader who wishes to learn more, the scope and accuracy of the references are very important. Except for some substantial works that appeared during the year preceding the book's publication, the references include almost all of the papers ever published on this subject. On a number of occasions, however, this reviewer noted references that were incorrect or incomplete. It is unfortunate that the references of such an important work were not carefully checked for validity. In contrast to this deficiency, every reader should find the thorough subject and author indexes of great value.

An unfortunate result of our technical communications system is that a paper, once published, can always be referred to " safely," even though it may have been negated or severely modified by subsequent published work. The instance in mind here is the discussion of the very early tests of Eldin and Collins on low-temperature fracture behaviour of steel (reference 31 and Fig. 67 of chapter 4). These tests served a vital purpose for several years as the only tests of their kind and were reasonably accurate if not interpolated. However, the present author states that the behaviour observed by Eldin and Collins is " well established." Yet tests conducted at least two years ago by Hahn, Owen, Averbach and Cohen (cf., for example, *Weld J. Res. Supp.*, vol. 38, '59, No. 9, pp. 367 to 376) that cover the temperature range in finer increments have demonstrated that in the region close to $-196°$ C the behaviour of mild steel is very different from the simple picture of Eldin and Collins. Because the differences between the two series of tests are so significant in explaining fundamental fracture mechanisms, this reviewer hopes that subsequent authors will not perpetuate this particular inaccuracy.

Special mention must be made of the author's splendid efforts to avoid using some of the unnecessarily esoteric terms that a few individuals have been attempting to force into the technical language. He is able to translate some current and confusing approaches to fracture mechanics into simple language without resorting to special terminology, but in the description of mechanical tests he is lured into talking a little-understood " language " that has been developed to describe a collection of miscellaneous empirical parameters. This reviewer believes that authors of technical papers who are chiefly concerned with communicating ideas should strive to use only well understood words and symbols in their presentations.

On a number of minor points this reviewer would like to offer rebuttal to the author, but such would not be appropriate to a review; perhaps the extent of stimulation of ideas in the reader's mind should stand as a good measure of the book's worth. From study of this book both the novice and the old-timer will benefit and be stirred to new thoughts on the problem of brittle fracture.

D. K. FELBECK

Trade Publications

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Materials

Degrease and Spray Phosphate. HELLERMAN LTD., Gatwick Road, Crawley, Sussex. Fospray is the name of a sprayable solution which needs no degreaser to preceed it. Forms zinc phosphate coating. 2 pp. unill.

Pvc Pastes and Primers. SCOTT BADER AND CO. LTD., Wollaston, Wellingborough, Northants. Data sheets on a range of pvc pastes and primers for use in casting, dipping and foamed pvc production. 14 pp. unill.

Maintenance Paints. CAMREX PAINTS LTD., Hudson Road, Sunderland. Booklet qualitatively discusses the range of paints made by this company. 56 pp, ill.

Molybdenum Disulphide Oil Additive. ROCOL LTD., Swillington, Nr. Leeds. Brief historical development of this additive and a few simple questions and answers on its use. 14 pp. ill.

Reinforced Plastics Tubing. PERMALI LTD., Gloucester. Brief details of properties and sizes of tubes made in recent association with Bristol Aerojet Ltd. 2 pp. ill.

Steel Extrusions. LOW MOOR FINE STEELS LTD., Low Moor, Bradford. Catalogue illustrating sections made by this company to customers' specifications. 50 sheets, bound.

Fuel Oil Improver. COMBUSTION CHEMICALS LTD., 33 Dorset Square, London NW1. Test results from use of Desulfurol sulphur inhibitor and fuel oil inhibitor. 12 pp. unill.

Suppliers of Processed Silicone Rubber. MIDLAND SILICONES LTD., 68 Knightsbridge, London SW1. Two lists of firms under classified products. 4 pp. unill.

Electrode Materials for Welding Equipment. ENFIELD ROLLING MILLS LTD., Brimsdown, Enfield, Middx. Alloys and forms. Technical data. 17 pp. ill.

Spectrochemical Analysis. HILGER AND WATTS LTD., 98 St. Pancras Way, Camden Road, London NW1. Part 2: source units. 23 pp. ill. Part 5: direct reading spectrographs. 23 pp. ill. Both include descriptions of equipment.

New Books

BBC Handbook, 1961. *British Broadcasting Corporation, Broadcasting House, London, W1.* (6*s*)

An authoritative reference work on the constitution, control, finances and activities of the BBC.

The Birth of a New Physics. By I. BERNARD COHEN. *Heinemann.* (5*s*)

The Copernican revolution and the subsequent conflict between Aristotelian and post-Renaissance physics—culminating in the publication of the *Principia*—are retold through the lives of Copernicus, Galileo, Kepler and Newton. There is a guide to further reading.

Bergbaumechanik. By J. MAERCKS and W. OSTERMANN. 6th Edition by W. Ostermann. *Springer-Verlag, Heidelberger Platz 3, Berlin-Wilmersdorf.* (36*DM*)

Already well established in Germany as both a textbook for mining colleges and a manual for the mining engineer, this work is a complete course in the applied mechanics of solids, liquids and gases, illustrated with examples drawn from mining technology. Theory of machines, strength of materials and elasticity, hydraulic machinery, throttled flow and pumping are among the topics which come within its purview.

Heat Engines. By E. DE VILLE. Teach Yourself Series. *English Universities Press.* (7*s* 6*d*)

An introduction to the study of heat engines, suitable for National Certificate and first-year university courses. Simple explanations (supported by worked examples) are given of the principles and operation of each type of engine, together with an outline of its history. There are numerous exercises, with answers.

Direct Current Machines. By H. B. RANSON and E. T. A. WEBB. 2nd Edition. *Cleaver-Hume Press.* (21*s*)

A largely non-mathematical account of the operation, construction and control of dc machines, including a fairly full treatment of dc motor starters and control gear. The utilization aspect is given more emphasis than in the first edition. The mks system of units is used throughout.

Progress in Cryogenics. Volume 3. Edited by K. MENDELSSOHN. *Heywood* (45*s*)

Six expert contributions summarizing recent advances in low-temperature technology: helium liquefiers; heat exchangers; refrigeration cycles and devices; rocket propellants; paramagnetic substances for nuclear orientation; dynamic nuclear orientation.

Engineering Metallurgy. By RAYMOND A. HIGGINS. Part 2: Metallurgical Process Technology. *English Universities Press.* (25*s*)

An introduction to the industrial methods used to shape and heat-treat metals and alloys (including powder metallurgy). Brazing, soldering and welding techniques are also covered.

The Reviewers

Mr. Stafford Beer is head of the Department of Operational Research and Cybernetics in the United Steel Companies Limited. He founded the department five years ago after building up one of the earliest operational groups at Samuel Fox and Company Limited, where he was also production controller. A member of several operational research, cybernetics and other societies and institutions, he read philosophy and psychology, at London University, and is the author of many papers and a book, *Cybernetics and Management* (EUP, 1959).

Mr. G. Berry, B.Sc., A.M.I.Mech.E., is in charge of the Noise Control Section at the National Engineering Laboratory of DSIR. He was formerly with Humber Limited of Coventry.

Dr. D. K. Felbeck, M.A.S.M.E., M.A.I.M.E., M.A.S.M., M.A.W.S., M.S.N.A.M.E., M.A.S.T.M. is at present executive director, Committee on Ship Steel and Committee on Ship Structural Design of the National Academy of Sciences-National Research Council. In September he takes up a position as associate professor of mechanical engineering in the University of Michigan.

Marketing

Power-Gas Process Plant for Poland

AGAINST intense competition from Italian, Dutch and United States manufacturers, the POWER-GAS CORPORATION Limited have won a contract from Poland for the supply of a urea plant producing 500 tons of a specialized product for use in fertilisers, a small proportion to be used directly as cattle feed.

This is the first Power-Gas contract in Poland. It is worth £1·5 million and is on a deferred payments basis. The corporation sent out a special technical and commercial team for the negotiations.

The PG urea plant is a complete recycle unit in two streams, using the Toyo Koatsu process, licensed to Power-Gas from the Japanese company, Toyo Koatsu. The contract is the first application of the process in Europe. In Japan similar plants have already been installed with a total daily output of about 1,500 tons.

The new plant is to be installed at an already existing ammonia producing plant in Poland. More units may be required as expansion takes place later. Delivery of the plant is scheduled for early 1963. It is to be brought into operation by Power-Gas and Toyo Koatsu operating personnel.

The greater part of the equipment will be provided from the United Kingdom, with the DAVY-ASHMORE Group, of which Power-Gas are members, carrying out the manufacture of the specialized units.

Power-Gas plant has recently been installed in a number of Eastern European countries. The company's engineers are currently working on a number of additional proposals for Poland and other Eastern European states.

Poland is in the process of carrying through a five year plan and the urea plant is the first of five to be built under schemes drawn up as part of the plan.

An Easier Life for Your Typist

Good typists are hard enough to find, and even more difficult to keep, so that any step that can be taken to make things easier for them, as well as to improve their output in terms of numbers of letters and reduction in errors is worth while. The West German company TIPP-EX VERTRIEB, of Frankfurt am Main, now market a simple and efficient method of leaving the typewriter eraser just sitting on the desk.

Their product is a slim strip of coated paper which, held over the mark typed in error, obliterates the outline when the same key is struck again, leaving on the paper a surface of the same colour as the original. The speed with which this can be used is not its only advantage.

The removal of the incorrect character is permanent and, from experiments conducted with Cop-Ex, which is for correcting mistakes in carbon copies, and with Tipp-Ex, which is for the top copy, there is no loss of appearance.

The importer of Tipp-Ex Type-Out and Cop-Ex Copy-Out in the United Kingdom is Leslie McLean Limited, of Richmond, Surrey. Pammar Marketing Limited are that company's distributors in the North of England.

Municipal Office Contract in "Crooked Valley"

A contract worth £400,000 for the first stage of the redevelopment of the Croydon municipal offices has been awarded to WATES Limited, the building and civil engineering contractors. The contract is for a five storey office building with basement car park.

With a parish church believed to have been founded by Christians in the army of Arulus Plautius in 64 AD, Croydon has a long association both with the Archbishops of Canterbury, who had a palace there, and with various Sovereigns—James I was kept a prisoner-guest in the Archbishop's palace. The name Croydon is believed to have come from the Anglo-Saxon *Crog doene*—the crooked valley—a reference to the local topography.

Expansion of services in the Croydon County Borough has long since outgrown the present Town Hall. The new developments will give house-room to all the municipal offices. The Wates contract is for a five storey building linked to the main Town Hall by a steel-framed bridge over Mint Walk, which is being widened as part of the general scheme of redevelopment.

The bridge will run from the Town Hall's first floor to the second floor of the new building. A subway will also connect the two office buildings.

The five storey building, of reinforced concrete frame construction, designed by Wates, in conjunction with the Croydon borough engineer, Mr. A. F. Holt, will be approximately 220 ft long by 43 ft wide, providing a gross floor area of 49,000 sq. ft. A three floor, semi-underground car park for 115 cars is to be provided at the rear, with ramp access from two roads.

Machine Tool £250,000 Order for Moscow Exhibitor

COVENTRY GAUGE AND TOOL, the machine tool manufacturers, have been awarded a contract by the Soviet authorities for a range of Matrix jig borers, gear grinders and thread grinders worth more than £250,000.

Coventry Gauge and Tool were among the machinetool makers exhibiting at the recent British Trade Fair in Moscow where they found a high level of interest taken by visitors to the Fair, particularly by those from the Russian import-export organizations.

The borers and grinders are to be delivered in 1963.

Salt from Seawater by Geothermal Heat

Salt is being produced from seawater in Fiji using geothermal heat from hot springs to evaporate the moisture in what is believed to be the first pilot plant of its kind.

The suggestion that salt should be produced in Fiji, using the geothermal heat, came first from the Burns Commission which investigated the land and population problems of the island. Fiji, with a consumption of 1,400 tons of salt each year, will have to evaporate 50,000 tons of sea water annually if the salt is to be provided without imports.

First results from the plant set up by the Land Department are reported by the Colonial Office to be promising.

Analysis of the early samples found that they contained 92·93 per cent salt. The target is 96 per cent. It is thought that with better control of fractional crystallization this should be achieved.

Vienna Conference on Export Insurances

Special consideration was given to the steps taken by a number of governments for export guarantees exceeding five years at the Vienna conference earlier this month of the Union d'Assureurs des Credits Internationaux, more usually known as the Berne Union. The United Kingdom member of the Berne Union is the Export Credits Guarantee Department.

The longer terms of more than five years for export guarantees are allowed in special cases and are of special significance for the newly developing countries, where long periods for payment are very frequently a necessity.

Twenty-one export credit insurance organizations were represented in Vienna plus observers from the International Bank of Reconstruction and Development and from the Japanese export insurance office.

A recurring feature of the periodic Berne Union meetings, this was the 18th, has been the exchange of information on the overall economic outlook in a number of markets and the terms of payment appropriate to a variety of goods. The same broad review took place at the recent meeting.

President of the Vienna session of the Union was Mr. L. J. Menzies, of the United Kingdom Export Credit Guarantee Department. A Belgian, Mr. A. Thomas, and a Swiss, Mr. H. Brunner, were elected president and vice-president for the coming year.

All Nippon Airways Receive First Viscount 828

The first of six Viscount 828 turboprop airliners to be operated by ALL NIPPON AIRWAYS, of Japan, has been handed over to the MITSUI Company at the VICKERS-ARMSTRONGS airfield at Wisley, Surrey.

With spares the value of the six aircraft is more than £4 million, which makes this the largest British aircraft export order for Japan.

While the delivery of the airliners has been awaited, All Nippon, who serve 27 cities in Japan, have been operating, on charter, two Viscount 744s.

The Viscount 828 is the All Nippon version of the Viscount 810, the latest and most advanced of this line of propeller turbine aircraft. Power is provided by four Rolls-Royce Dart R Da 7 engines giving a cruising speed of 365 mph at heights above 20,000 ft.

Soviet Oil Supplies in London Tankers

The British tanker fleet owned by LONDON AND OVERSEAS FREIGHTERS LIMITED is to continue and extend its carriage of Soviet oil.

The first contract announced by London and Overseas Freighters (LOF) was announced last September for the transport of about 1 million tons of oil over a two year period. Now a new contract has been arranged worth about £4 million a year in freight revenues and employing three quarters of the 16 strong LOF tanker fleet.

At the moment LOF tankers are carrying Soviet oil to Western Europe, Japan and Cuba, among other places.

British Companies at Major Polish Fair

Radar equipment, printing machinery and plastics are among the British exhibits provided by more than thirty companies taking part in this year's International Trade Fair at Poznan, Poland (11 to 25 June).

The British pavilion, covering 12,000 sq. ft, house a series of stands by companies who have collaborated with the Board of Trade in participating in the Fair. Almost all the products on display are capital goods, following the known Eastern bloc preference for importing the means of manufacturing consumer goods rather than buying the consumer goods from outside.

Mining equipment, machine tools, commercial vehicles, mechanical handling gear, scientific instruments, agricultural machinery and diesel engines are all being shown by the British companies.

Planetary Axle Agreement with USA Manufacturer

An exclusive licence to manufacture and sell in the United Kingdom the Rockwell Standard range of planetary axles has been granted to CENTRAX Limited, of Newton Abbot, by the United States ROCKWELL STANDARD CORPORATION.

These axles, in use all over the world, have a capacity up to 150,000 lb and are known for ruggedness, reliability and versatility. For each planetary steering axle there is an operationally matched rigid axle. Among the planetary axles' features are hypoid gearing, balanced planetary wheel ends, floating ring gear, full float lubrications and a high degree of interchangeability of parts.

Applications for the axle include four wheel drive tractors, front end loaders, heavy duty commercial vehicles, large dumpers, scrapers, mechanical handling and mining equipment.

Recording Equipment for Irish Television Sound

The sound recording equipment of RADIO EIREAN'S television film dubbing suite is to be provided by the WESTREX Company, of Cricklewood, North London, a member of LITTON INDUSTRIES.

The equipment, which will be all 16 mm, includes specially designed re-recording and recording machines. A Westrex 1216 Portable 16 mm magnetic recording channel is being supplied direct from the Westrex Hollywood Centre plus certain ancillary equipment to be manufactured in London.

Some idea of the standing of the Westrex products in this field of the entertainment industry is contained in the record of the Academy of Motion Picture Arts and Sciences' award of merit for the best sound. Twenty-seven times in thirty-one years this award has been won with Westrex recordings.

Solartron SC 30 Analogue Computer

Solartron entered the analogue computer market by starting with the operational amplifiers and working up to a complete medium capacity machine.

THE Solartron SC30 Analogue Computer is a maid-of-all-work. To be a general purpose analogue machine it must be capable of tackling a wide variety of problems and be reasonably simple to operate. Furthermore, it must maintain its operational accuracy for long periods without demanding special working conditions or too frequent attention for setting up.

The SC 30 is, by nature, particularly useful for analysis of the dynamic behaviour of physical systems. Any mechanical, electrical, biological or even economic system involving motion in time may be studied, provided that equations defining the behaviour of individual parts of the system can be formulated. Once this has been done, an exactly analogous system may be set up on the computer and the overall behaviour studied, before any of the system actually exists physically either in whole or in part.

Digital and analogue computers represent two essentially different approaches to automatic computation. The digital computer in its simplest form may be likened to a highly complex and sophisticated calculating machine, which operates arithmetically on numbers supplied to it, usually employing a binary scale. Its virtue lies in the speed with which it can perform complex calculations. The use of electronics enables it to perform hundreds or thousands of simple operations every second and produce the answer within an extremely short time.

The analogue computer works differently. It simulates electrically the system to be studied; in other words it provides an electrical analogy for a physical system. Every reader will be familiar with the "water analogy" used by lecturers to introduce to students the behaviour of an electric circuit—the analogue computer uses the same principle in reverse. It is therefore useful where the physical system to be studied becomes complex due to the number of variables; for instance, the behaviour of a vehicle suspension which is acted upon simultaneously by a number of constantly varying dynamic forces. The only satisfactory way of studying such a system other than by lengthy "trial-and-error" calculations, would be to use high speed photography on a model or experimental prototype.

The analogue computer in its simplest form is usually termed a "simulator," and is intended to deal with one particular kind of problem. A general purpose machine, therefore, capable of tackling a wide range of problems, is going to tend to become exceedingly complicated and expensive. Yet, in order to succeed in its aim, it cannot demand an operator who is highly skilled in computer techniques. A sacrifice of some kind must be made, without seriously jeopardising its practical utility.

Agonizing compromises, such as that which faced Solartron when they decided to introduce the term "general purpose" into automatic computation, are not uncommon in engineering. Almost invariably the whole success of the future product depends upon the final interpretation, which in this case boils down to simplicity of operation versus range of application.

Product Profile has already revealed a surprising number of instances where success of a machine to perform a certain task depended initially on the realization that in the great majority of cases an operational sacrifice of some kind, either of performance or convenience, is admissible. The resulting product sells in far greater quantity than would a more specialized machine, hence keeping down the price and bringing the facility which it affords within the reach of many more customers. In the same way the aims of Solartron in producing the SC30 can be summarized; and in this particular case the right compromise may be regarded as the proportion of linear to non-linear facilities.

YOUNG COMPANY

The history of the Solartron Electronic Group Limited, a young company which is now a member of the Firth Cleveland Group, is one of commendable individual enterprise and good management. The story started in 1947 when two men without university degrees, but with plenty of keenness and sound technical knowledge, E. R. Ponsford and L. B. Copestick, decided to enter the rapidly expanding field of electronic equipment. They started business on their own at Kingston-on-Thames repairing Government test equipment, and were soon under regular contract.

Then they began manufacture on their own, starting with regulated power supplies. In 1952 the two original partners were joined by Mr. J. E. Bolton, a graduate of Cambridge and Harvard Universities, whose financial investment in the company and close touch with the electronics market set the stage for the rapid expansion that the company has enjoyed ever since. In 1953 additional premises at Thames Ditton were acquired, and production included signal generators and oscilloscopes.

The next move was to set up a development team. The first fruit was a radar simulator introduced at the end of 1955 after a careful scrutiny of the future prospects of systems application. The radar simulator is a system of radar training in which a simple form of analogue computer plays a vital part. Coincident with its introduction, the research and development facility was moved to new quarters in Dorking, Surrey.

The company's entry into the field of analogue computers was a gradual process which occurred, surprisingly, at a time when other British firms were dropping out. The earliest builders of analogues were aircraft firms who urgently needed them to solve airframe problems. Today the tendency is for specialized analogue users to purchase components from a firm like Solartron, who have a large turnover of 5-amplifier "modules", and build them up into a computer unit of virtually any size and requirement.

After the radar simulator, Solartron's next step was to sell separately the component operational amplifiers and power supplies for customers to build into their own machines. Next the company started thinking in terms of a complete system with racking in which to mount it, so forming a packaged unit. The result was the 5-amplifier module introduced in 1957, which immediately became popular and which still sells in large quantities.

Each module represents a linear computing unit in its own right. Together with the nest of amplifiers and a built-in heater, it includes a control box and power distribution panel. With the addition of a "patching panel", on which a problem can be set up, it is sold as the Analogue Tutor: a simple computer useful for students at undergraduate level for demonstrating, among other things, analogue computer techniques.

However, Solartron still yearned to produce a reasonably sophisticated and versatile computer; one that would appeal particularly to schools and universities and yet be relied upon

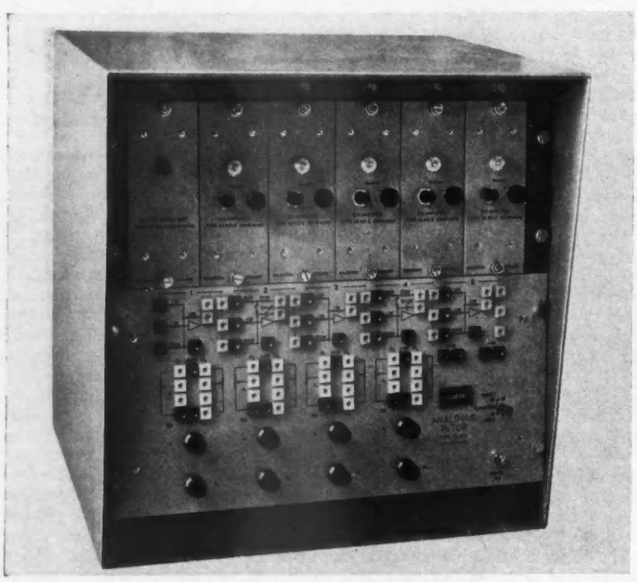
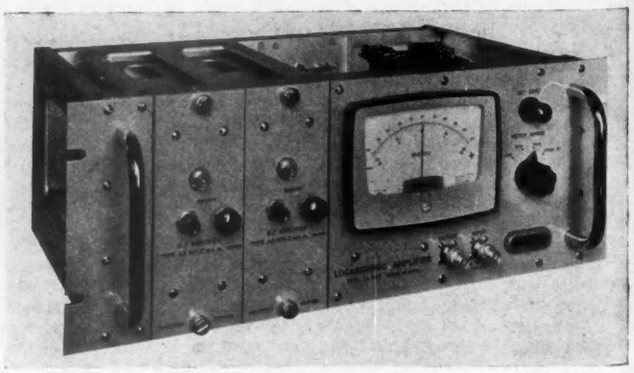


Fig. 1 (left) The Analogue Tutor.

Fig. 2 (below) Logarithmic amplifier unit.



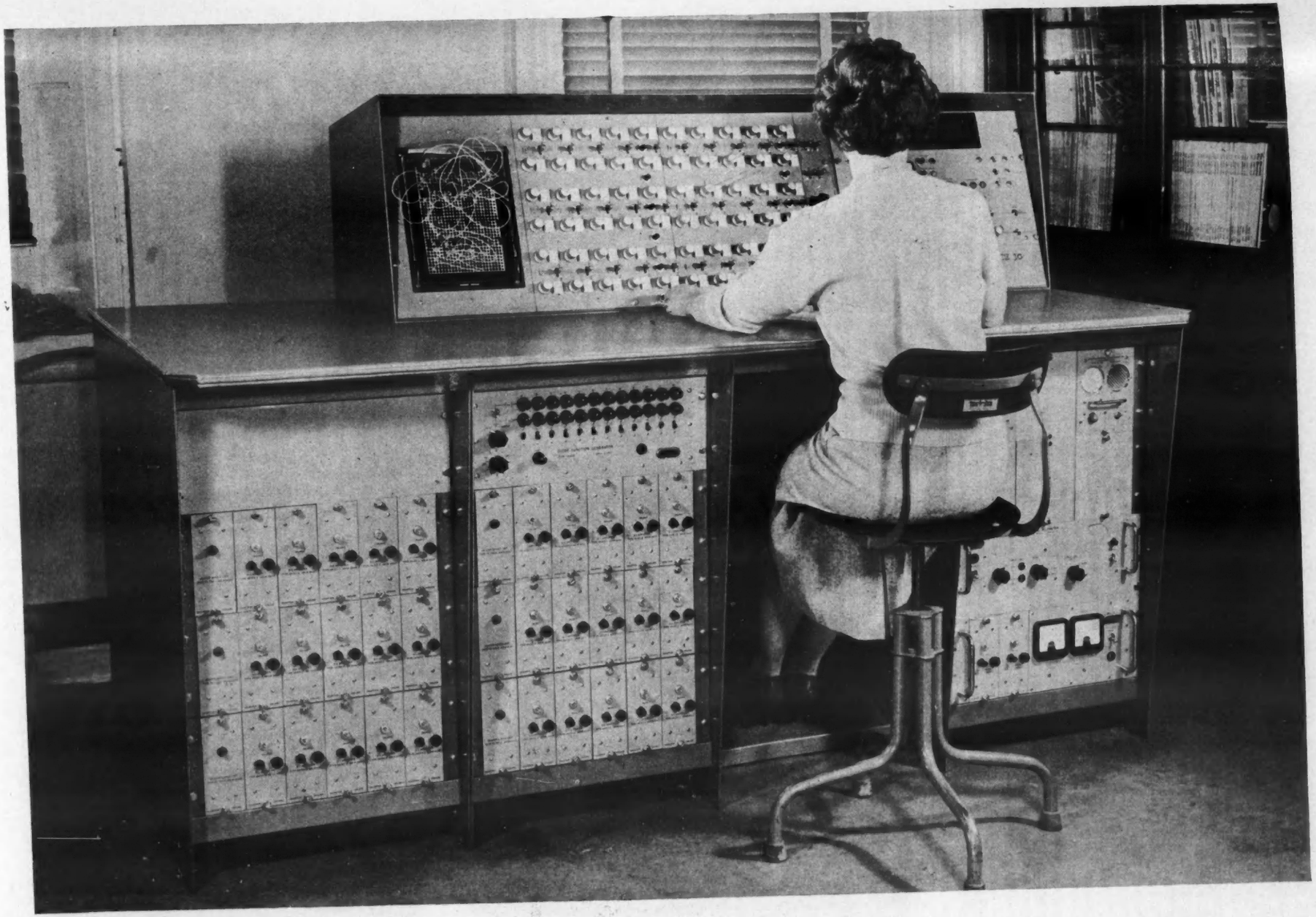


Fig. 3 A striking proof of success assured by new approach—an accommodating and yet dignified machine.

as a " bread-and-butter " product. Their chance came in 1958 when the General Electric Company and British Nylon Spinners each ordered a machine, to be composed mainly of standard units that already existed. The GEC one was completed and exhibited at the end of the year—Solartron's prototype general purpose analogue computer.

Apart from restyling there was little difference in the production version, which was named the Minispace due to its compactness. It is now known as the SC10 and over forty have been sold. It contains ten operational amplifiers—the basic minimum for solving a reasonably wide range of linear dynamic problems.

The success of the SC10 was well up to the company's expectations, and the first units were hardly out of the shops before serious consideration was being given to the next move. That a bigger unit was needed was unquestioned, but how much bigger should it be? At the time a machine with 40 to 50 operational amplifiers was the popular favourite, and a 48-amplifier unit was actually constructed. But a critical study of the potential market, assisted by the Computer Exhibition at Olympia in 1958, caused the company to embark instead on a 30-amplifier machine, tailored to a price which would ensure a reasonable degree of acceptance. More elaborate and sophisticated circuitry would compensate for the sacrifice of versatility imposed by the reduction in the number of amplifiers.

The result was the highly successful SC30. The first two were ordered by BTH off the drawing board with the result that they were both delivered before the end of the year. Thus Solartron had progressed through the amplifier—module—small computer—medium capacity computer stages in a mere three years.

SELLING PROBLEMS

The SC30 has introduced marketing problems of its own, since selling a machine of the kind is vastly different to selling modules. They are relatively inexpensive and the company sell a steady flow of them, virtually " off the shelf," throughout the year. Being small they do not account for a high proportion of shop capacity.

The SC10, representing as it does a capital investment of £1,600 or so by the purchaser, is inclined to be a seasonal requirement. When it came to the SC30, involving a capital investment of over £10,000, the problem was accentuated. The instant of ordering is so often dependent upon yearly or half yearly budgeting.

So Solartron find themselves selling SC30's in satisfactory quantity but irregularly. The steps they have taken to iron out the fluctuation to approach a reasonably steady flow of production are worthy of closer study.

The most critical aspect is that inevitably certain vital, expensive, long-delivery components will have to be bought out. Generally Solartron order such components two machines ahead of their own orders. Production is governed by a probability theorem, in other words a guess is made by the technical sales organization as to the likelihood of obtaining orders during, say, the ensuing 6 month period.

Such a policy demands close liaison between the sales and production departments, and involves an element of risk in that large items of capital equipment might have to be stored if the reasoned guesswork fails; but in practice it has so far paid off handsomely. Over a dozen SC30's have been sold up to the present, the majority of which have been dispatched within about six weeks from the order—virtually off-the-shelf when it is considered that each machine possesses certain minor peculiarities. Short deliveries are a definite sales aid.

Perhaps the most striking feature of the SC30 is the styling, the desk type console representing a vast improvement over post office rack type mounting. The appearance was treated with importance because computers are usually showpieces and occupy a place of honour in the customer's premises. The console was designed entirely within Solartron's own organization, and it has been highly commended by the Council of Industrial Design.

The centralized problem or " patch " board shown in Fig. 6 is detachable and duplicated so that the computer need not be out of action while a new problem is being set up. With an analogue computer the problem is set up by plugging and wiring together the required facilities. In the SC30 the patch board is of the AMP type, imported from the USA. It is 816-way with diallyl phthalate insulation, and the layout has been statistically chosen so that many continually recurring connections are made with 2-way links to avoid clutter.

Presentation of numerical input and output is obtainable from a five-digit digital voltmeter which can be used to operate an additional remote read-out and a print-out device. The high degree of accuracy and repeatability of the complete machine is one of its strongest points. Materials are now obtainable for the electronic components which give a life tolerance of 0·1 per cent or less at moderate cost.

When the user sets a problem he starts by using linear approximations, and when they do not fit he ventures into non-linear. With many kinds of problem the linear facilities quickly tend to become saturated, hence the need for a relatively high proportion of non-linear facilities on a computer sufficiently flexible to meet the majority of cases. Individual customer requirements are made as easy as possible by the ability to plug in extra facilities, or to run one, two or three SC30's together under one control. One of the snags in selling a computer is that the customer himself is often not clear as to his precise requirements.

An unconditional year's guarantee, except on valves, is offered with each machine and replacements are sometimes made free of charge outside the guarantee period. During the first year visiting service staff make three complete checks —and a " flying squad " service is always ready.

Another triumph for a company comparatively young in the computer field is the establishment of a computer centre used for both demonstration and computer time hire. Each new computer is tried in operation at the centre, where faults of the kind that shop component inspection would miss can be traced and rectified.

The SC30 is definitely an engineer's tool, not just a mathematician's. While three-quarters of the SC10's go to teaching institutions, the SC30's customers consist mainly of national and engineering research centres, divided roughly 50-50 between the UK and overseas.

Solartron Electronic Group Limited have recently moved their headquarters to Victoria Road, Farnborough, Hants, where a 15-acre site is rapidly being developed. A virile organization of this kind never stays put for long.

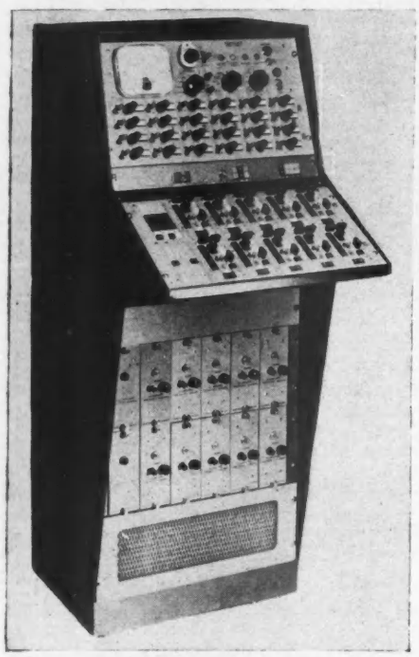


Fig. 4 (top left) The SC 10 analogue computer.

Fig. 5 (right) Digital voltmeter as fitted to the SC 30.

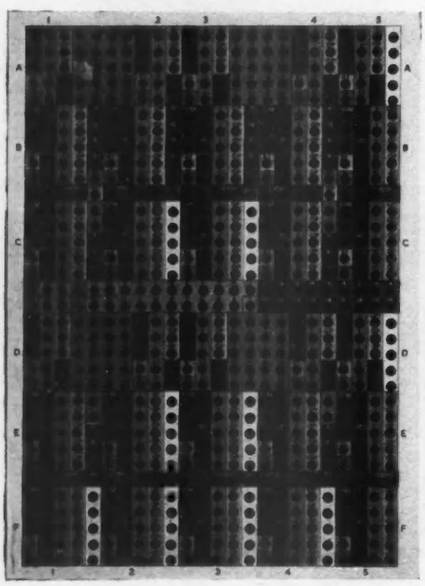


Fig. 6 (bottom left) Arrangement of patch panel.

Model Used to Test Thermonuclear Theory

Some years ago, after research work on controlled thermonuclear reactions became de-classified, the UKAEA decided to house all its activities in this field in a new laboratory. This is to be the Culham laboratory and it is now under construction at Culham, near Harwell.

A variety of thermonuclear research projects, including the now-famous Zeta, will be housed in the new laboratory, where national and international exchange of information will be a regular feature.

One of the projects to be centred at Culham in the near future is concerned with a novel technique for creating and holding a plasma. A code name has not yet been given to the project, but for the moment it is known as the Harwell Mirror Machine Experiment. The basic idea for the experiment—a new magnetic field configuration—was originally proposed by a Russian scientist, K. D. Sinelnikov.

The plasma will be formed by injecting high energy particles into a magnetic field and holding them there by arranging that the magnetic field lines have undulations of the same wavelength as the spiralling particles. In this way, theory predicts that a "stable" random plasma will be formed with at the same time a low rate of loss of the particles.

In an effort to carry theoretical studies as far as possible before starting to "cut metal," an electronic analogue model has been devised. This device, in which electrical quantities are made to vary with time in the same manner as the physical quantities being investigated, has been used to provide a clearer understanding of the overall problem. Two-dimensional plots showing the behaviour of particles in a corrugated magnetic field have been obtained from the model and these show that, if collisions between individual particles can be ignored, the particles will behave more-or-less in the predicted manner, i.e., they will oscillate between the mirror ends of the machine to form a stable plasma.

The next stage of the project will be to carry out experimental studies on the mirror machine, which is now under construction. One of the first experimental studies will be to determine the interaction between individual particles during the build-up of the plasma.

The machine will be smaller than Zeta and will have a better vacuum in its plasma chamber—Zeta's working pressure is about 10^{-6} mm Hg, whereas the new machine will achieve a pressure of 10^{-9} mm Hg.

Large oil diffusion pumps, using up to date oils with low impurity properties, will form the basic evacuation unit. Final vacuum will be achieved by means of titanium getters, which can be almost continuously evaporated so that the ultimate vacuum will last for several days, or even weeks. Titanium cleans up hydrogen (the plasma constituent) at a very fast rate.

Solar Cells for Marine Buoys

Research Engineers of Trinity House are currently investigating the possibility of using solar cells to power marine buoys. Already a number of experimental installations have been built, both at Trinity House and at their research station at Dungeness, Kent.

At present, marine buoy lighting relies almost entirely on the use of stored gases, such as propane or acetylene, the gas being used not only to provide the light, but also to control the character of the flash. Systems like this have been in use for many years and have proved extremely economic and efficient. However, it is necessary to replace the gas cylinders, often under adverse weather conditions, at an interval of approximately twelve months.

With the advent of the silicon photo-voltaic cell, or as it is more commonly known, the solar cell, which converts energy from the sun or from incandescent lamps into electrical energy, Trinity House research engineers turned their attention to its possible application to marine buoy lighting. They recognized that the use of the solar cell would be advantageous, particularly from the maintenance viewpoint, because of its extreme reliability. Indeed, there appears to be no special reason why such a cell should ever fail and experiments carried out by the manufacturers (Ferranti Limited) bear this out. Over periods of up to 20,000 hours, there is no evidence of change in the device. It has a response time of a few microseconds and can operate without deterioration under conditions of high temperature (− 40° to + 125° C) and humidity.

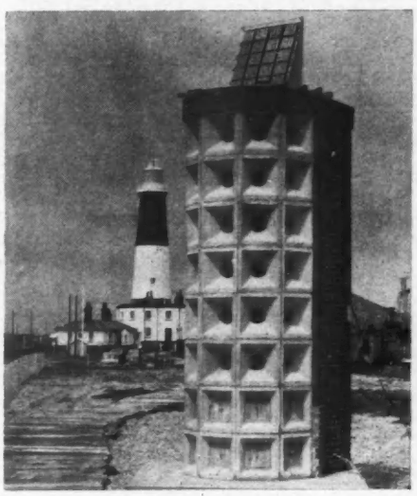
Solar cells were first produced some years ago at the Bell Telephone Laboratories in the USA. When used as a means for the direct conversion of solar energy to electrical power, they form the most efficient power source yet known. Efficiencies of the order of 6 to 10 per cent for the conversion of light energy to electrical energy have been achieved.

Ferranti Limited were the first manufacturers in the United Kingdom to produce cells of this type to act as photo-sensitive devices in punched tape and card readers for industrial control and instrumentation. This range has subsequently been enlarged to include types suitable for power generation.

In their planned programme of research which is of necessity long-term in nature, Trinity House research engineers have already established practically that despite the unfavourable English climate, solar cell installations can provide the necessary power throughout the year to charge a small battery. However, because of the many problems still to be solved, they do not anticipate that the first fully equipped marine buoy installation can be available for operation before the end of 1963.

Experimental equipment which has already been built takes the form of a spherical glass bulkhead type fitting in which a block of four silicon solar cells, wired in series, are mounted at an angle of inclination of latitude + 15°. This ensures that a maximum charge is given to the 1·2 volt Nife storage cell throughout the year. In peak sunlight conditions the maximum daily charge is of the order of 250 milliampere-hours. Each cell provides about 0·4 volt on load.

A large experimental installation containing 400 solar cells, wired in series parallel has been made, the power derived from this bank being used to charge ten Nife storage cells. This is intended for use on navigational lights situated in river estuaries, and it is hoped that investigations carried out on this installation will reveal whether it can be used successfully as the main source of power for operating a light without having to rely on a shore-based electrical installation.



This installation, at Dungeness, contains 400 solar cells.

Hydraulic Model for Tees Estuary

The Tees Conservancy Commissioners wish to increase the depths seawards of the entrance channel in the Tees Estuary from 25 ft to 40 ft below low water, and they intend to reclaim large areas of tidal foreshore inside the estuary. Before completing their plans, the Commissioners approached the DSIR Hydraulics Research Board with the following requests: (1) to examine various methods by which the depths seawards of the entrance channel can be increased without excessive maintenance dredging; (2) to investigate the effects of reclamation inside the estuary on tidal heights and on depths in the river and entrance channel; and (3) to consider various proposals that have been put forward for improving the deep water channel inside the estuary.

The results of this work are given in the current annual report of the Hydraulics Research Board.

A mobile-bed model, with scales of 1/200 and 1/60, was built in one of the larger wave basins at the Hydraulics Research Station. This model reproduced the waves, the tides and the currents caused by the interaction of the tidal currents in the North Sea with those in the estuary.

The rate at which a dredged excavation filled up in the prototype was compared with the rate at which a similar excavation filled up in the model; this gave an approximate scale for bed movement. Experiments were made to find the rate of dredging which would be required to maintain increased depths of up to 40 ft in a channel seawards of the river entrance and also to find the effect of extending the southern breakwater—when the breakwater was extended in the model, the ebb current flowed strongly against it while the currents during the flood were distributed evenly across the mouth of the estuary and were much weaker than those of the ebb. Further tests on these proposals are now being made.

A second model now being designed will be used to study the effects of reclamation works, and of various improvements to the channel inside the estuary. An extensive field survey has already been carried out by the Station's survey team to provide information for the design and proving of the model and to investigate the general conditions in the estuary. Several large areas of sand between low water and high water have been surveyed, velocities have been observed and samples of salinity and suspended solids taken at 14 points in Tees Bay and in the estuary.

XUM

Applied and Fundamental Hydraulics

To meet the increased pace of competition in hydraulics engineering, the Glenfield Group have recently opened a new research laboratory. It is one of the largest and best equipped of its kind in Britain. For some work models are used.

HAVING long ago established a reputation as leaders in the field of hydraulic engineering, Glenfield and Kennedy Limited, Kilmarnock, are still enjoying prosperous times. However, up-to-date scientific techniques are increasing the rate of technological advance, so that engineering skill and "know-how" are no longer sufficient to command competitive supremacy. Recognizing this, the Glenfield Group decided to build a research and development laboratory which would enable them to give improved service to customers and, more important still, to maintain leadership in new designs. This laboratory was officially opened on 8 June in the presence of many of Britain's leading hydraulics engineers.

The terms of reference of the new laboratory are broadly set out under three headings: (1) to carry out hydraulic flow tests under controlled conditions on established products in order to determine soundness of design and to aid development; (2) to provide basic data which may be essential when establishing new designs; and (3) to have a source of fundamental information related to the broad field of fluid control.

In terms of the first objective, much of the initial activity will be concerned with obtaining precise data under simulated site conditions on the performance of a number of established products. This involves the determination of data in regard to head loss, operating flow, operating characteristics, discharge characteristics, anti-slam qualities, jet distribution, hydraulic torque, etc. At the same time, work will proceed on the development of new designs and on hydraulic scale model research such as dam intakes, spillways, free discharge regulators and other projects for the controlled flow of large volumes of water.

The second and third objectives fall into the field of applied research. Distinct from the fundamental research often undertaken by universities, this type of work is intended to obtain information related to a specific parth of development.

The objectives of the new laboratory are somewhat exacting. They demand installations and equipment that have been carefully planned to allow for many various projects, both at the present and in the future. A study of the types of problems likely to be encountered has shown: (1) pressure heads and flow ranges must be extensive and flexible; (2) working space must be sufficient to allow for flexibility of layout; and (3) test equipment must be capable of giving a high degree of accuracy and, once again, it must be flexible.

Main Storage Tank

A central wall divides the main storage tank into two channels, each 10 ft wide, which help to promote circulation within the sump and provide support for the working floor. The walls and floor of the tank are covered with a rubber-based chlorinated paint.

The tank has two salient features: (1) a large surface area allows the escape of entrained air; (2) it can be used for large scale free surface flow experiments—vertical grooves in the walls being provided at intervals for the erection of control gates.

The tank is supplied with metered fresh water through a 3 in inlet at the south end. This inlet is fed from a 1½ in dia pipe connected to the town's water supply, and provision is made for the incoming flow to pass through filtration apparatus before it enters the tank.

For experimental purposes, water is drawn from the north end of the tank through the pumps and returned to the south end by an overspill pipe from the constant head tank. This permits entrained air to escape before the water is recirculated. An overflow weir is provided to convey any overspill to a drainage sump.

Four armoured glass ports along the east wall of the tank allow visual inspection of underwater test rigs, thus the tank is a useful feature of the laboratory and not merely a sump for dead water.

Drainage Sump

A drainage sump, at the east end of the pump bay, based 4 ft below floor level, measures 8 ft by 4 ft.

In addition to accepting overspill from the main storage tank, working floor and ground floor, the sump is also employed to empty the main tank or to drain from the debris sump of the main tank.

Two automatic drainage pumps are provided to empty the sump into the town's drainage system. These each have a capacity of 105 gallons per minute and are powered by 5 hp electric motors. The switch arrangement is ball flow operated in two stages. The units may also be switched from the pump control gallery.

Fixed Pipe Lines

The fixed pipe lines of the laboratory connect the pumps to the constant head tank, and the pumps and overhead tank to the working floor.

The principal feature of the layout is that, with the exception of the vertical risers to the constant head tank, all pipes are below working floor level.

The valves are hand operated sluice valves with the exception of one electrically actuated unit in the main supply line. Provision is made for the substitution of these valves by valves of other design for the purposes of long term "site" testing.

The pipe arrangement is such that the pipes may be connected singly, in series, or in parallel to the working floor either via the constant head tank or direct. In either event, the pumped water may be passed through any one of three venturi meters before reaching working floor level. If required, sub-circuits permit the pumped supply to be passed through pressure reducing valves before reaching floor level.

On the east side of the laboratory the pumped supply is available through one 12 in, two 8 in and two 6 in dia pipes, and on the west side through six 15 in dia pipes.

All right angle bends in the system are of the cascade type—i.e. a mitred bend with internal vanes. The virtue of these is the lack of distortion of velocity profile after water has passed the bend; thus, despite the large number of bends, water reaches the laboratory floor with a good velocity profile and without swirl. Headloss on the bends is fairly low.

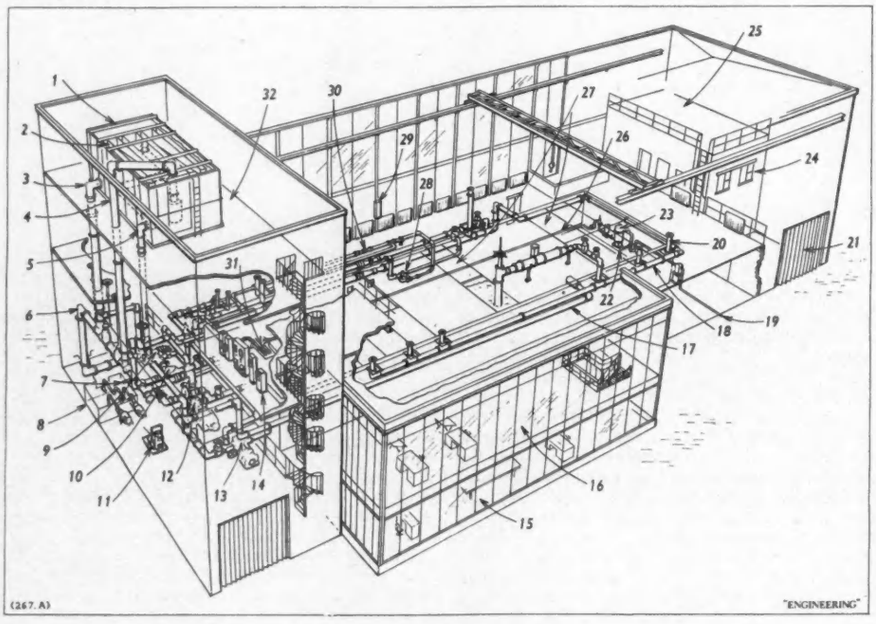
Constant Head Tank

The constant head tank is made up of pressed steel sections and measures 24 ft by 12 ft by 8 ft.

Water enters the tank from the pumps through a syphon, which prevents return flow, and rises until the level is intercepted by an overspill weir in the form of horizontal open channels hung from above. These channels provide a 136 ft length of weir. Water overspilling into the channels is discharged into the bay end of the tank where it flows by gravity through a 12 in dia pipe back to the north end of the storage tank. In this way, water may be drawn from the tank for use on the laboratory floor from a known and constant level.

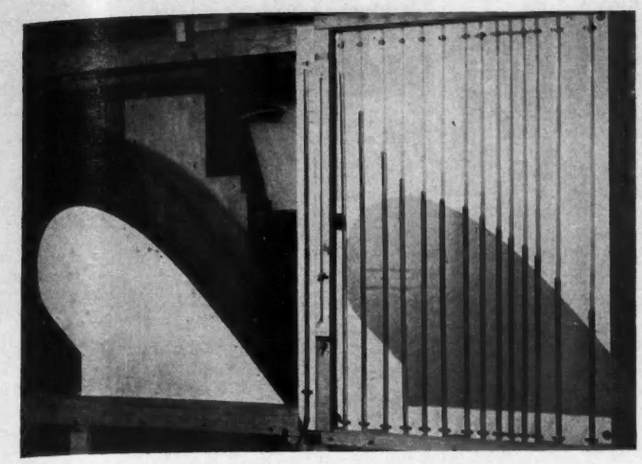
Filtration

To keep the laboratory water clean, it is abstracted from the north end of the main storage tank in a 3 in dia pipe, passed through the filtration plant and pumped back to the tank through the south inlet. During the working day water from the main storage tank is pumped continuously at the rate of 5,000 gallons per hour through a filter and returned

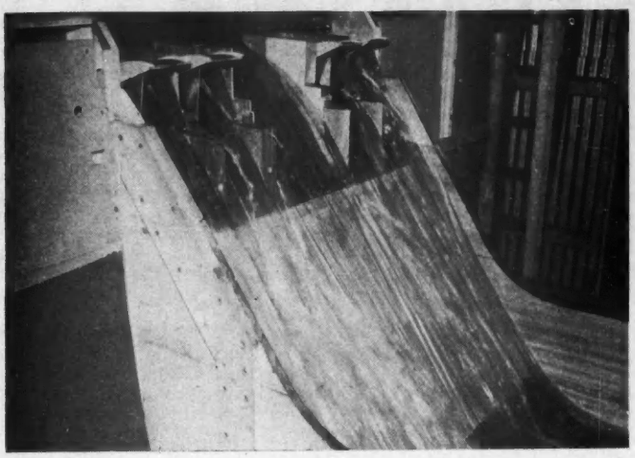


One of the main features of the new laboratory is the flexibility of its services and working space.

1 Constant head tank
2 Overflow weirs
3 Constant head draw-off pipe
4 Inflow to header tank
5 Overspill from header tank
6 Main bus pipe to working floor
7 Draw-off pipe from main tank
8 Drainage sump and pumps
9 Pump A
10 Pump B
11 Air compressor
12 Pump C
13 Pump D
14 Pump switching gear
15 Conference room
16 Design office
17 Header tank overspill
18 Bus pipe serving working floor
19 Town water supply
20 Off-take pipes at floor level
21 Loading bay entrance
22 Inlet to main tank
23 Filtration and chemical injection plant
24 Machine shop
25 Pipe storage area
26 Filtration circuit
27 Removeable main tank covers
28 Break pressure valves
29 Main manometer board
30 Venturi bank
31 Outlet from main tank
32 Aerodynamics laboratory



Hydraulic model to determine correct profile for automatically controlled spillway.



Scale model of dam spillway, controlled by four radial gates and a drum gate.

to the tank. Thus, the total capacity of the tank is filtered in a period of 16 hours.

For corrosion inhibition, sodium nitrite is injected, and to control possible algae growth provision is made for the injection of a bacteriolytic solution.

Hydraulic Flow

The laboratory flow system is self-contained. Water is pumped from the main storage tank through a test rig and then returned to the storage tank for recirculation. The head and flow available for the test rig at floor level can be within a defined range from a suitable pump or combination of pumps.

The use of two 10 cusec units (installed at the laboratory) connected singly, in series, or in parallel, provides a large range of flow at heads from 35 to 130 ft. The variation of flow with head obtainable from the 10 cusec pumps is shown in the graph, from which it can be seen that the units can be combined to give several effects:

(1) One or both pumps can deliver through the overhead tank, as shown by the hatched areas of the graph, to give any flow up to 20 cusecs at a constant head of 35 ft.

(2) By suitably adjusting valves, either pump can deliver, direct to the working floor, flows of less than 10 cusecs at pressures up to 65 ft.

(3) The two pumps, coupled in parallel, can deliver flows of less than 20 cusecs at pressures up to 65 ft.

(4) By connecting the delivery branch of one pump to the overhead tank, and the overhead tank to the suction of the second pump, and running both pumps at once, the head due to the height of the overhead tank can be added to that given by one pump under arrangement 2. In this way, flows and heads up to 10 cusecs and 100 ft can be obtained.

(5) By connecting the delivery branch of one pump directly to the suction branch of the other pump, and passing the flow in series through the two, the pumping head can be doubled. In this arrangement, flows and heads up to 10 cusecs and 130 ft can be obtained.

For flows below 2½ cusecs and for heads of 35 ft or less, a 2½ cusec pump can be used through the medium of the constant head tank which delivers water to the floor under a head of 35 ft. Smaller pressure heads can be obtained by routing the water through one of the pressure reducing valves of the fixed pipe system.

For test rigs requiring flows of less than 1 cusec and at heads of up to 450 ft, a multi-stage turbine pump is used, connected directly to the working floor.

Flow Measurement

Generally, flow is measured by a manometer on the working floor, connected to one of the three venturi meters. The size of the meter used is chosen to give maximum accuracy for the particular flow range in question. The water flowing through the test rig is regulated either upstream of the test rig by sluice valve or, whenever possible, downstream of the rig by one of two discharge valves specially designed for the purpose.

The three ways in which flow can be measured in the laboratory are by: (1) standard venturi meters; (2) measurement of weight per unit time; (3) orifice plates.

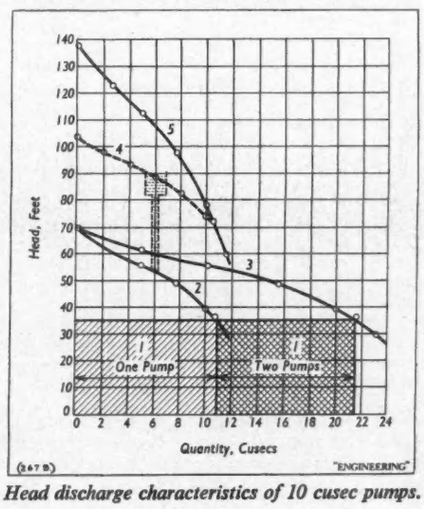
As mentioned above, most of the measurements are made by venturi meters, three of which are installed in the fixed pipe lines. An arrangement of valves at each end of the bank permits the selection of the meter most suitable for measuring the quantity in demand. In addition, all three meters can be used separately so that three measured quantities can be delivered to three independent test rigs. The capacities of the meters are given in the table.

TABLE:—*Venturi Meter Capacities*

Venturi meter	Straight pipe diameters		Discharge coefficient	Flow range (water at 15° C) *cusec*
	Up-stream	Down-stream		
			Per cent	
6 in dia	37	12	0·9837 ± 0·20	*0·6– 1·8
12 in dia	20	16	0·9908 ± 0·25	1·3– 6·0
18 in dia	16	14	0·9902 ± 0·25	4·0–20·0

* The 6 in meter can be used for flows down to 0·4 cusec with a suitable adjustment to the discharge coefficient.

The meter bodies are of Meehanite cast-iron with phosphor bronze throat liners. Pressure tappings are led from each meter to manometers on the working floor. Mounted on the manometer board is a multi-valve block which allows any one of the three meters to be connected to either a mercury or a tetrabromoethane manometer.



Head discharge characteristics of 10 cusec pumps.

For flows less than 0·6 cusec, or up to 2 cusecs, which may require very accurate metering, measurement by weight per unit time is available. Water is weighed in a portable tank and weighbridge having a capacity of 2 tons of water. The flow to be measured is diverted into the tank for a period of time which can be precisely determined.

Control Valves

A necessary requirement for all flow control valves is freedom from fluctuations of flow and pressure during operation. The accuracy with which experimental results can be measured is often limited by the effects set up by the valves.

Two kinds of valves are used in the laboratory, both designed specially for laboratory work.

The first is called a "pot valve." This consists essentially of a perforated cylinder that, in service, is submerged in the main storage tank with its axis vertical, having an internal sleeve by the linear movement of which the number of exposed perforations can be varied. The layout and size of these performations allow the relationship between the discharge and degree of opening of the valve to be varied within quite wide limits. In addition, when fitted with an outer perforated screen, the design has the characteristic of discharging quietly below surface level without the entrainment of air.

In the case of the Glenfield laboratory pot valves, the relationship between discharge and degree of opening defined by the length of stroke is also linear. In this way, the flow through a test rig can be adjusted within fine limits.

The second control valve is intended for use with the weighbridge. It is a spear type valve, similar to that commonly used for Pelton wheel nozzles, constructed of Meehanite with a zinc-free bronze spear and gunmetal faces. A 90° bend turns inflowing water downward in a vertical direction past the spear and nozzle. Discharge is to atmosphere with a linear relationship between flow and valve travel. The flow regulation is accurate, the headloss small, and discharge is in the form of a smooth circular jet for all flows.

Below the valve is a "fishtail" transition which converts the incoming jet of circular cross-section into a long thin rectangular jet. This jet impinges upon a diverter having two stable positions which correspond to the flow into the measuring tank and to waste, respectively.

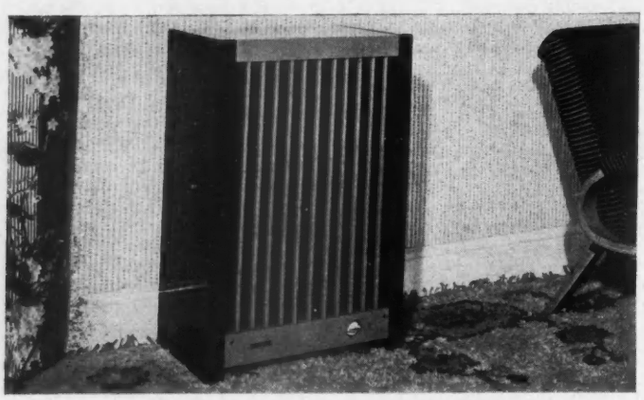
The period of flow into the tank is measured from the time the tongue of the diverter passes through the centre of the jet, diverting water into the tank, to the time the tongue passes the centre moving in the opposite direction. This method of flow measurement has been proved highly accurate by the Fluids Division of the National Engineering Laboratory.

Storage Heating

For those who are planning now for new heating systems next winter the recent announcement by Thermodare (Great Britain) of a domestic version of a block storage heater at last brings this convenient and economical system within the reach of the ordinary householder. Hitherto, only commercial models have been available owing to difficulties with purchase tax.

The D25 shown in the illustration measures 30½ in high by 22 in wide and 12 in deep. It is rated at 2½ kW and will plug-in to standard socket outlets. At the bottom right is a thermostat control which is adjustable to individual requirements. The top grille and base panel are in a soft contrasting tone to the pastel shade of the main body. Provision is made for controlling the output and there is a thermal link to give protection against overheating.

Block storage heaters for commercial premises have been available for some years and, since they utilize off-peak tariffs, have proved themselves an attractive alternative to floor heating systems, especially as the latter are normally only possible in new constructions. Comparative tests were carried out by the Electricity Council over more than one heating season, using block storage heaters as against oil and coal-fired systems, direct-acting electrical systems and electric floor heating. The results have been published in Utilisation Research Report No. 14 (1960). Apart from the comparison of costs, the report contains some interesting figures on temperature-comfort levels among the occupants of the 11 premises over which the tests were made. In considering the results, it should be borne in mind that the relative costs of fuels are liable to change and that some minor adjustments to the figures may now be necessary.



The advantages of the block storage heater are now available to the domestic user with the Thermodare D25 unit.

In the summary, it is stated that little difference was found between block storage heaters and floor-heating installations in respect either of performance or cost. However, for a building initially fitted with a gas-fired central heating system, running costs and capital charges were some 15 to 20 per cent lower with the block heaters. Of three premises originally equipped with solid-fuel boilers, the actual electricity costs were about 50 to 100 per cent higher than the corresponding annual fuel bills, but, on the final count, the total annual cost in one case was 15 per cent lower and in the other two up to 20 per cent higher when the block system was used. This was allowing for labour charges, which would not apply in ordinary houses. The capital costs of the two types of system did not differ substantially.

The capital cost of a block heater system to replace a direct electrical-heating arrangement is two to three times as high and the consumption was found to be up to 50 per cent greater. The total annual cost, however, depends on the local tariff in force and the method of assessing the fixed charge. As a result, in two cases the final costs for the block heater system worked out at 20 per cent lower and in two others at 20 per cent higher. The poor load factor of the direct-heating systems was brought out by the tests.

The Council conclude from their results that thermal storage block heaters are competitive with any other method of office heating but that savings in consumption could be effected by improved methods of automatic control, particularly as regards overheating during mild weather; and by the addition of some means of enabling the heat output to be controlled manually. These features are included in the Thermodare domestic model but were not available at the time the tests were made. Some of the original block heaters have since been replaced by controllable-output types and further tests are being made. Tests on methods of control are also continuing. It must be remembered, too, that all the tests were carried out in office premises; it might well be that the results would have to be modified slightly for domestic use.

The control of off-peak floor warming is the subject of a paper that was delivered to the EDA sales conference at Harrogate (held earlier this year) by Mr. A. F. Hardcastle of the Southern Electricity Board. Most of the work refers to multi-storey flats for which special reference is made to the question of landlord or tenant responsibility for supplies. Weekly consumption figures are quoted for a period of a year for both floor heating and domestic services, and, in the appendix, there are lists of the appliances that were present in each flat. Annual and capital costs are given for three control systems, namely: individual time switches; time switch and contactor in multi-storey buildings; and centralized systems of control comprising the dc bias system, the rhythmatic system, and a pilot wire in the distribution mains similar to the arrangement used for the control of street lighting.

The whole subject of heating buildings by off-peak electricity supply is dealt with in a report produced by the Heating and Ventilating Research Association (Bracknell, Berkshire); the three main methods of storage considered being those by water, underfloor heating systems and block heaters.

Reckoning a comfort range of 62° F to 68° F (values which compare closely with those given by the Electricity Council), a design temperature of 65° F is recommended and full calculations for heat losses are given with due allowance for air changes. A point is made that a floor-heating system designed for a room without a carpet will be unsatisfactory if one is later fitted. Also, the heat loss from a top-floor room is greater than from an intermediate one and, therefore, greater loading must be allowed. Seasonal requirements are the next factor and these, of course, vary from place to place according to the severity of the climate. Architecture and air infiltration as a result of wind-induced vacuum are other points considered in what must be accounted one of the fullest design studies yet produced on this subject.

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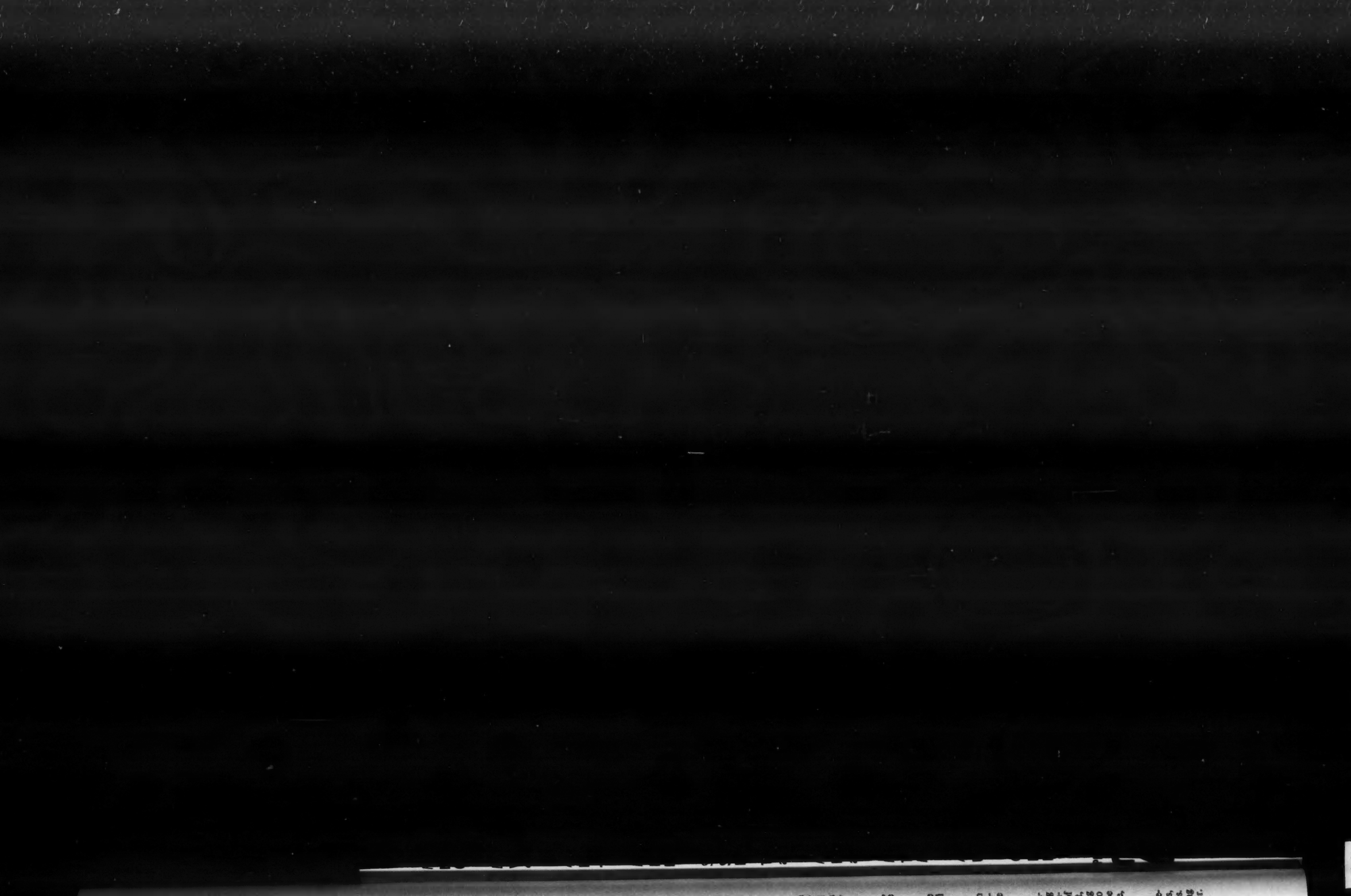
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